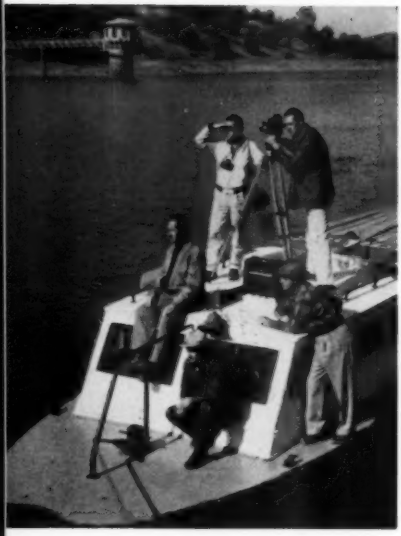
MARCH 1959

Journal

VOL. 51 • NO. 3

AMERICAN WATER WORKS ASSOCIATION



Putting Pardee in picture to keep East Bay MUD in the public eye

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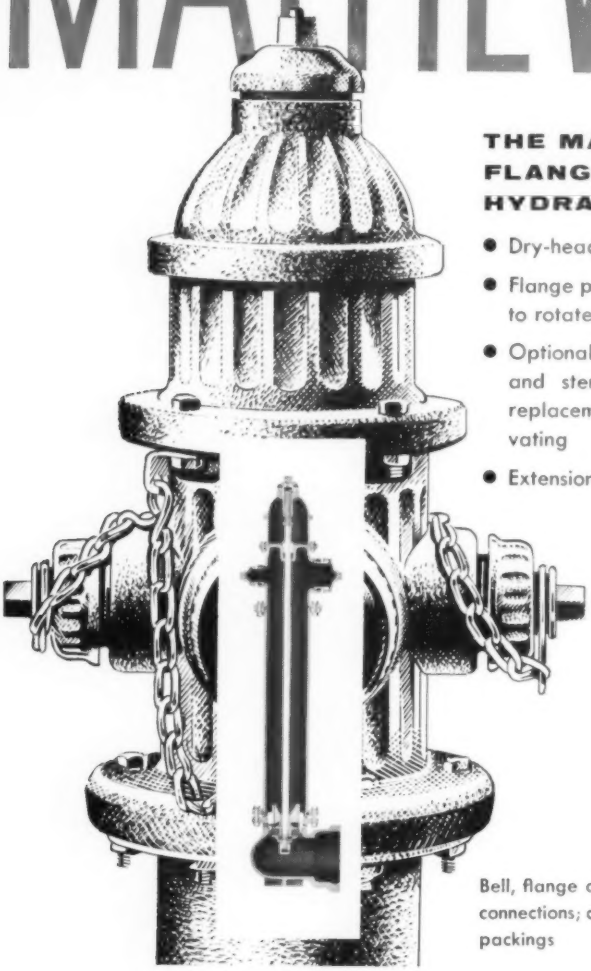

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San Francisco, Calif. Jul. 12–17, 1959

Official reservation forms being mailed to all members are returnable to AWWA postmarked on or after (but not before) noon, Mar. 16.

Coming Meetings

AWWA SECTIONS

Winter-Spring 1959

Mar. 11–13—Illinois Section, at Morrison Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 3440 Prudential Plaza, Chicago 1.

Mar. 19—New England Section, at Statler Hotel, Boston, Mass. Secretary, J. E. Revelle, Dist. Sales Mgr., Chicago Bridge & Iron Co., 201 Devonshire St., Boston 10, Mass.

Apr. 5–8—Southeastern Section, at Wade Hampton Hotel, Columbia, S.C. Secretary, N. M. deJarnette, Engr., Water Quality Div., State Dept. of Public Health, 309 State Office Bldg., Atlanta 3, Ga.

Apr. 8–10—New York Section, at Powers Hotel, Rochester. Secretary, Kimball Blanchard, New York Branch Sales Office, Neptune Meter Co., 2222 Jackson Ave., Long Island City 1.

Apr. 9–11—Montana Section, at Jordan Hotel, Glendive. Secretary, Arthur W. Clarkson, Asst. Director, Div. of Environmental Sanitation, State Board of Health, Helena.

Apr. 15–17—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, Rupert C. Ott Jr., Repr., Neptune Meter Co., 2818—21st St., Columbus.

Apr. 16–18—Arizona Section, at Hi-Way House Hotel, Phoenix. Secretary, Stanford I. Roth, Supvr. of Water Collections, Div. of Water & Sewers, Phoenix.

Apr. 22–24—Kansas Section, at Besse Hotel, Pittsburg. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina.

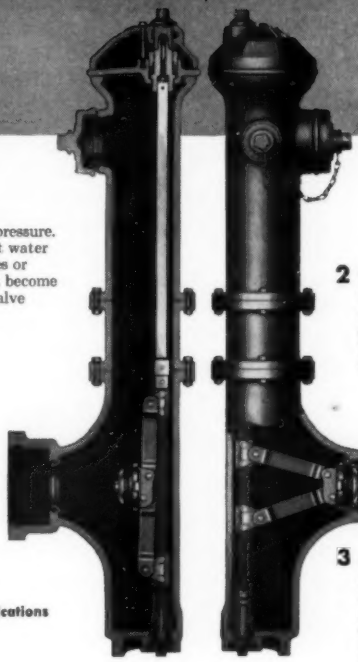
Apr. 23–25—Pacific Northwest Section, at Vancouver Hotel, Vancouver, B.C. Secretary, Fred D. Jones, W. 2108 Maxwell Ave., Spokane 11, Wash.

May 3–6—Canadian Section, at Queen Elizabeth Hotel, Montreal, Que. Secretary, A. E. Berry, Gen. Mgr. & Chief Engr., Ontario Water Resources Com., Parliament Bldgs., Toronto, Ont.

Jun. 3–5—Pennsylvania Section, at Salem House, Wernersville. Secretary, L. S. Morgan, Chief, Mine Drainage Sec., 413 First National Bank Bldg., Greensburg.

(Continued on page 8)

Here is why farsighted city officials install IOWA fire hydrants



1 FAST WATER
Opens fast, with the pressure. Closes slowly, without water hammer. Sticks, stones or foreign matter cannot become lodged between the valve and valve seat.

2 FULL FLOW
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Oskaloosa, Iowa

Coming Meetings

(Continued from page 6)

Fall 1959

Sep. 9–11—Wisconsin Sec., Milwaukee.

Sep. 14–16—Kentucky-Tennessee Sec., Lexington, Ky.

Sep. 16–18—New York Sec., Upper Saranac Lake.

Sep. 23–25—Michigan Sec., Saginaw.

Sep. 27–29—Missouri Sec., Kansas City.

Oct. 7–9—Chesapeake Sec.

Oct. 14–16—Iowa Sec., Des Moines.

Oct. 18–21—Alabama-Mississippi Sec., New Orleans, La.

Oct. 18–21—Southwest Sec., New Orleans, La.

Oct. 22–24—New Jersey Sec., Atlantic City.

Oct. 28–29—West Virginia Sec., Parkersburg.

Oct. 28–30—Ohio Sec., Dayton.

Oct. 30—California Sec., Bakersfield.

Nov. 4–6—Virginia Sec., Roanoke.

Nov. 9–11—North Carolina Sec., Durham.

Nov. 15–19—Florida Sec., Tampa.

OTHER ORGANIZATIONS

Mar. 16–25—Short course on "Environmental Health Aspects of Nuclear Reactor Operations," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Apply to USPHS regional office director or to Chief, Training Program, R. A. Taft Sanitary Engineering Center, 4676 Columbia Pkwy., Cincinnati 26, Ohio.

Mar. 16–20—National Assn. of Corrosion Engineers, Sherman Hotel, Chicago, Ill.

Mar. 16–20—Western Metal Exposition & Congress, sponsored by American Society for Metals and other technical groups, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif. Write: Ray T. Bayless, Asst. Secy., 7301 Euclid Ave., Cleveland 3, Ohio.

Apr. 2–3—Southern Municipal & Industrial Waste Conference, sponsored by Duke, North Carolina, and North Carolina State universities, at University of North Carolina, Chapel Hill, N.C.

Apr. 5–10—5th Nuclear Congress, Public Auditorium, Cleveland, Ohio, including Nuclear Engineering & Science Conference, sponsored by AWWA and other societies; Atomic Energy Management Conference, sponsored by Atomic Industrial Forum and National Industrial Conference Board; Hot Laboratories & Equipment Conference; and Atomfair, sponsored by Atomic Industrial Forum. Write: T. A. Marshall Jr., Mgr., 1959 Nuclear Congress, c/o Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

Apr. 6–10—American Welding Society, Sherman Hotel, Chicago, Ill.

May 4–8—ASCE Convention, Cleveland, Ohio.

May 5–7—Industrial Waste Conference, Purdue Memorial Union, Bldg., Purdue Univ., Lafayette, Ind.

May 18–20—Symposium on Instrumental Methods of Analysis, sponsored by Instrument Society of America, at Shamrock-Hilton Hotel, Houston, Tex.

Jun. 2–4—Appalachian Underground Corrosion Short Course, School of Mines, West Virginia University, Morgantown, W.Va.

Oct. 12–15—Federation of Sewage & Industrial Wastes Assns., Statler Hilton Hotel, Dallas, Tex.

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for
RAPID SAND FILTER

FILTER SAND SPECIFICATIONS are carefully laid out. The Effective Sizes and Uniformity Coefficients used by Consulting Engineers and also recommended by the American Water Works Association are the result of long years of research and experience.

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Muscatine, Iowa

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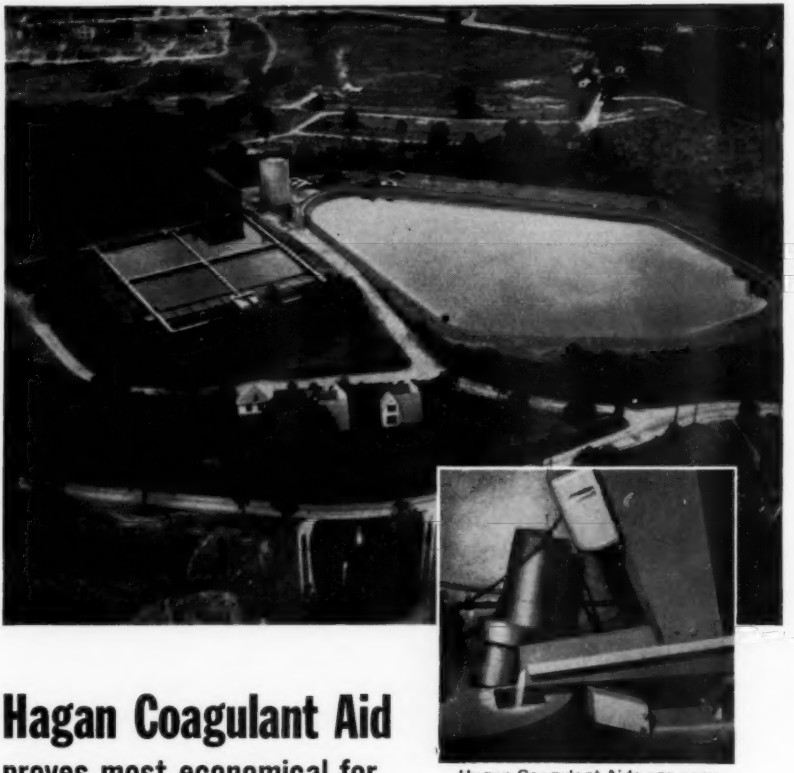

Hagan Coagulant Aid

proves most economical for Wilkinsburg, Pa., plant

Hagan Coagulant Aids are easy to feed. They can be dry-fed or fed as a solution. The Wilkinsburg plant uses this dry feeder to put Coagulant Aid No. 18 into solution.

The Wilkinsburg-Penn Joint Water Authority plant uses Allegheny river water that is high in manganese. Careful tests established lime, potassium permanganate and alum treatment to be the most effective method for manganese removal. However, the precipitate was finely divided, slow to settle, and carry-over of floc clogged filter beds.

To speed floc settling, the chief chemist tried both activated silica, and, with State Health Department approval, Hagan Coagulant Aid No. 18. Both were given laboratory tests and plant tests of several weeks' duration. At the end of the testing period, it was found that both gave equally good results at comparable chemical costs. However, the fact that Hagan Coagulant Aid could be dry-fed, while the preparation of the activated silica sol was a time-consuming task, made Hagan the obvious choice.

Nearly two years of usage has proved that Hagan Coagulant Aid works well with the other treatment chemicals over the full range of fluctuation in raw water characteristics. These Aids are non-toxic, easy to handle and feed, and produce a large tough floc that speeds settling time and reduces carry-over.

Write for Bulletin 410-12-2 for information on the complete line of Hagan Coagulant Aids.

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DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto

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have never been equaled for the accurate registration of all rates of flow, and for many years have maintained long and consistent records for performance at a minimum of cost.

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Sizes 2"- 3"- 4"- 6"
Inclusive
as illustrated
also
Iron Case Meters
(not shown here)
in sizes 8"- 10"

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(Established 1859)

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BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA — DALLAS — CHICAGO
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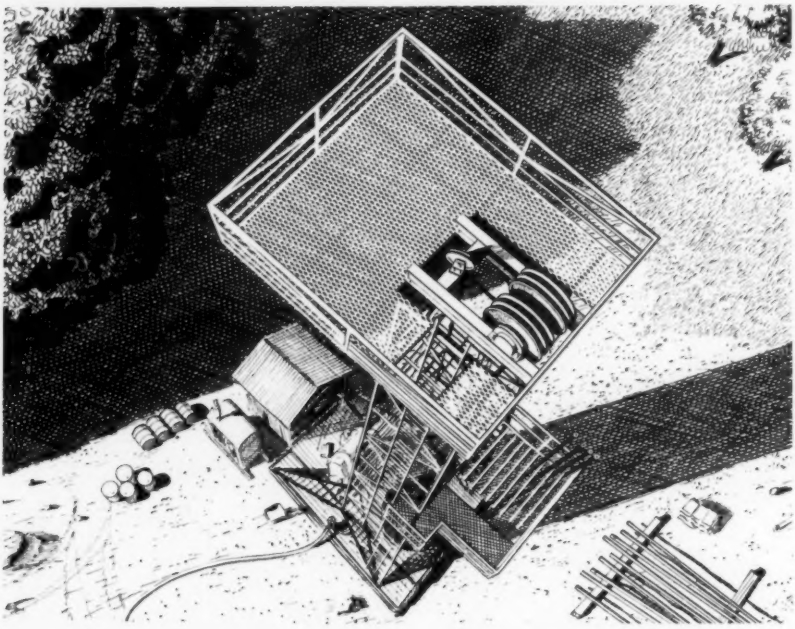
"You can't buy a better Water Meter than HERSEY."



RIGHT...from the top down

A good, dependable water supply system is no better than its beginning. The best beginning is a Layne drilled water well. Layne is the largest water well drilling organization in the world with over 75 years experience. Trained crews operate over 500 drilling and service rigs throughout the country.

Layne service doesn't stop there. A dependable Layne Pump specially designed for the job to deliver a specified QUANTITY of water, and Layne water treatment service to supply the exact QUALITY of water desired, are part of a complete job with undivided responsibility. But, that's not all. Layne maintenance and repair service wraps up the complete package. Your nearby Layne Company is as close as your telephone, so, call on Layne for a dependable water supply, right . . . . . from the top down, all backed by Layne Research.

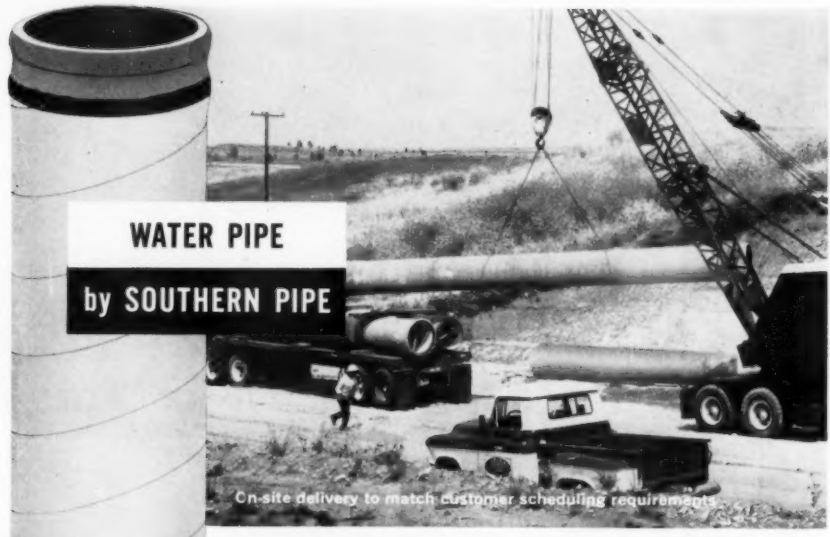
Layne **WELL DRILLING**

and other allied Drilling Services

LAYNE & BOWLER, INC., MEMPHIS

Offices and Factory, Memphis 8, Tennessee

Water Wells • Vertical Turbine Pumps • Water Treatment



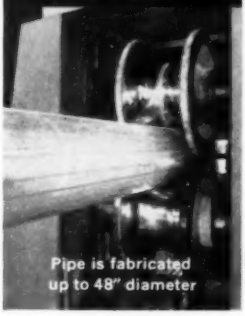
CENTRALIZED RESPONSIBILITY

Southern Pipe customers enjoy these ONE LOCATION benefits for welding, fabrication, coating, and lining of water pipe:

ONE LOCATION for—

- **all phases of job inspection**
- **all phases of custom and stock pipe fabrication**
- **steel pipe production PLUS any combination of coatings and linings desired**
- **continuous quality control**
- **integrated scheduled production**
- **constant understanding of job requirements**
- **improved contractor coordination**

Write now for literature describing the most completely integrated installation of protective coating, lining, and pipe producing equipment in the west.



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Southern Pipe

DIV. OF U.S. INDUSTRIES, INC.
P.O. Box C · Azusa, California
CUmberland 3-7111 · EDgewood 7-1221

AT TEN PLANTS ACROSS THE COUNTRY, Jones receives tank cars of Chlorine, repackages it in cylinders and 1-ton tanks, makes quick deliveries to users in area.

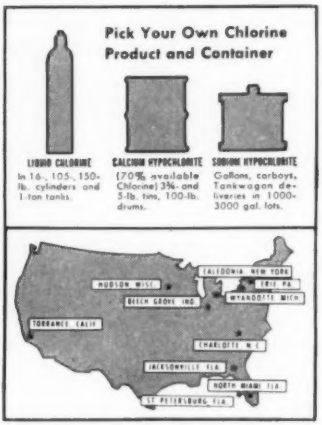
ONE convenient source for all your chlorine needs

Get chlorine products any way you want them, in any amount you need, from just *one* dependable source—Jones Chemicals.

It eliminates hop-scotch buying of liquid chlorine, calcium hypochlorite, or sodium hypochlorite, and enables you to plan your needs and deliveries . . . avoid excess storage. Ten Jones plants, strategically located across the U.S., stand ready to deliver chlorine products *when you need them.*

Get chlorine in any amount—from 16-lb. cylinders to 1-ton tanks. Jones packages high-purity chlorine in less than carload lots—then lets you pick the size and type of container you need.

Our trained technical staff will be glad to help you with your chlorine problems. Write for information and prices, or contact the Jones plant nearest you.



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"A good name in chemicals"

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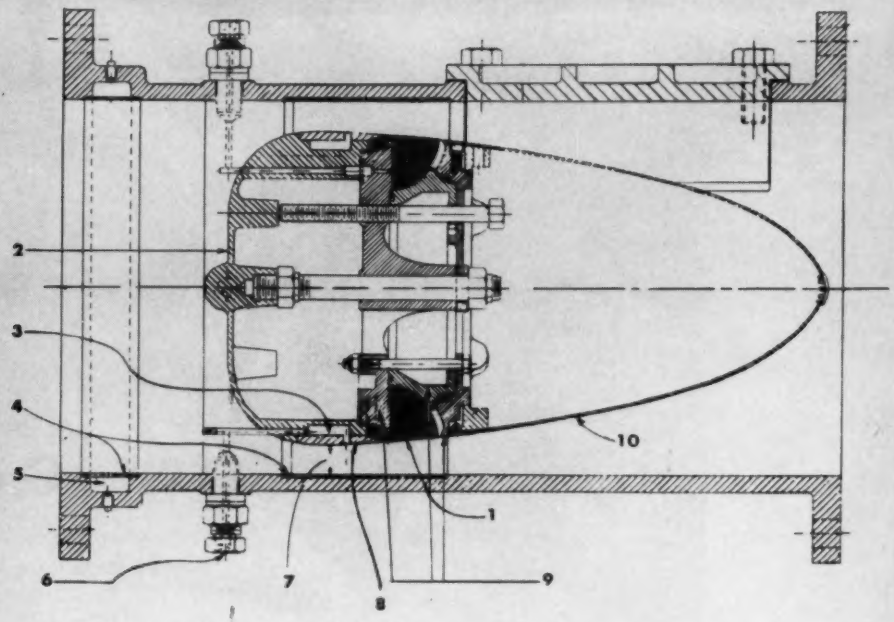


1. *Only moving part* is this modulator.
2. Nose piece.
3. Multi-piezometer low-pressure chamber.
4. Housing liner.
5. Multi-piezometer high-pressure chamber.
6. Low-pressure connection.
7. Annular throat.
8. Throat ring.
9. Modulair assembly—clamping ring, spacer, and holding ring.
10. Head recovery section.

Maintenance is nil

because only one part moves in the new Modulair Flow Controller

Take the moving parts out of a rate-of-flow controller and you've taken away practically all your maintenance—and that's just what you can do with this new Simplex Modulair Flow Controller.

The only moving part inside your pipeline is a non-corroding rubber throttle.

There are no line valves, no pilot valves, no pistons or valve shafts. Not even a stuffing box to pack.

Installs like a piece of pipe. You can install a Modulair in about the time it takes to plumb a piece of pipe. It comes as a completed unit.

New bulletin. Bulletin 951 explains the Modulair design in greater detail and shows pictures of installations where Modulair has been in actual filter plant operation for over seven years.

SIMPLEX®
VALVE AND METER COMPANY
a subsidiary of PFAUDLER PERMUTIT INC.
LANCASTER, PENNSYLVANIA

PRIMITIVE WASHDAY...Washing in a river —inefficient and exhausting—is still done in many undeveloped countries. Clothes never really come clean and are often contaminated.

THE MODERN WOMAN merely turns a switch...her wash is done automatically in clear, pure water—most of it carried through cast iron pipe.

U.S. cast iron PIPE

FOR WATER, SEWERAGE AND
U. S. PIPE AND FOUNDRY COMPANY

but better than ever today!

From mine-to-line, U. S. Pipe controls quality

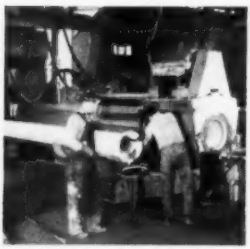
America's water systems... finest on earth... didn't just happen.

They are made possible by forward-looking water officials and the dependable cast iron pipe that carries most of the nation's water.

We supply much of that pipe. To make sure it's as good as human care, skill and integrity can make it, U. S. Pipe controls every production step. From mining of ore to modern packaging, our pipe is tested, checked and rechecked for quality every step of the way.

Dependability is built into U. S. Pipe... literally, from the ground up!

PROBING THE EARTH... Our own iron ore is mined from deposits as much as two miles distant from the portal



INSPECTING HOT PIPE... U. S. Pipe, just removed from the mold, is checked and inspected for quality.

SCIENTIFIC TESTING... Determining the chemical properties of U. S. Pipe – one of many quality checks.

INDUSTRIAL SERVICE CAST IRON

Birmingham 2, Ala. *A wholly integrated producer from mines and blast furnaces to finished pipe.*

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When you invest—
Get the best—
Buy
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MAXIM evaporators

are under constant test at the enlarged Maxim Test Station in Waterford, Connecticut. Full density sea water, in continuous supply, assures the best possible conditions for research, development and testing — another reason why you can specify Maxim with confidence.

Maxim Evaporators may be the answer to your potable water problems. Write for full information.

extra benefits from MAXIM Test Station

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Maxim Division
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EMHART

Last Look...

BECAUSE CONCRETE CYLINDER
PRESSURE PIPE MEANS
VIRTUALLY NO MAINTENANCE

You aren't likely to see *this* pipe again—because it's Concrete Cylinder Water Pressure Pipe, a product that's made to *stay* underground, silently, diligently serving future generations.

For example—a large midwestern city has never spent a maintenance penny on more than twenty million inch feet of Concrete Cylinder Pressure Pipe—while its total water pipeline repair costs have run into millions of dollars in the last ten years.

That's why water works operators say Concrete Cylinder Pressure Pipe is "as maintenance free as pipe can be"—one more good reason why you should contact Concrete Cylinder Pressure Pipe manufacturers in *your* area for your water pipe needs.

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 N. LA SALLE STREET
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Concrete
PRESSURE
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WATER FOR GENERATIONS TO COME

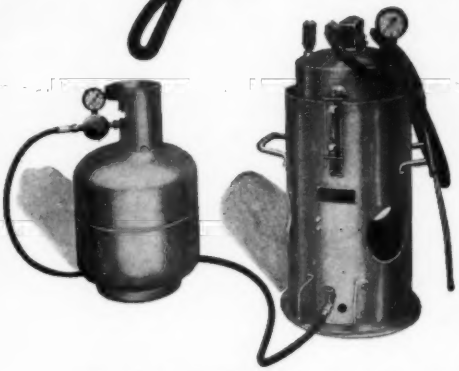
NOW, YOU CAN

forget frozen hydrants

use an

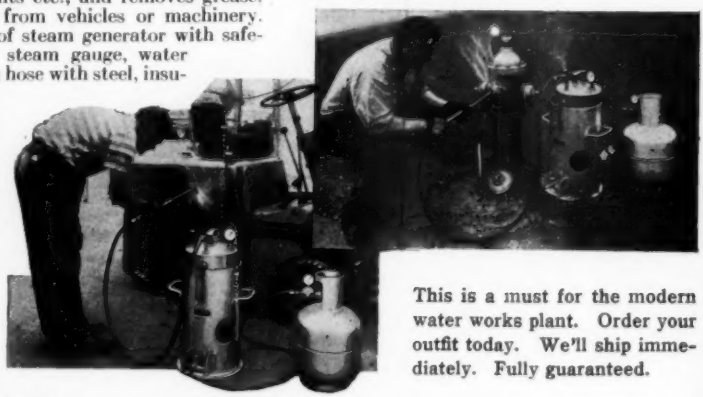
L-P GAS BURNER

STEAM THAWER



THIS IS THE FASTEST MOST SUCCESSFUL THAWING DEVICE KNOWN IN THE WATER FIELD . . .

Here is the most practical, most effective, thawing device ever offered the water field. Thaws water pipes, valves, hydrants etc., and removes grease, frozen mud or dirt from vehicles or machinery. Three gallon rustproof steam generator with safety valve, 30 pound steam gauge, water gauge, 6 feet of steam hose with steel, insulated nozzle that can get into tight spots. Can be refilled without shutting off burner. Weight 95 lbs.—20 lb. propane gas cylinder comes with burner—extra cylinders always available.



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This is a must for the modern water works plant. Order your outfit today. We'll ship immediately. Fully guaranteed.

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PDM
ELEVATED STEEL TANKS

When your elevated water storage needs are

large in scale

depend upon the unequalled experience of

Pittsburgh-Des Moines

Pittsburgh, Pa. 2,500,000 Gallons

Elevated steel tanks of largest size are supplied by PDM to meet the increasing water storage volumes required by America's ever-expanding communities.

- Engineering of highest excellence, precision fabrication and sure craftsmanship in erection have distinguished Elevated Steel Tanks by Pittsburgh-Des Moines since 1897. Write for prompt quotations.

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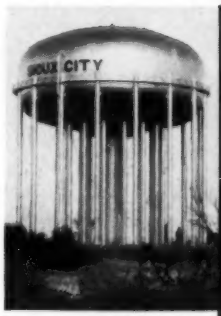

Sioux City, Ia.
2,000,000 Gallons

Fort Wayne, Ind.
1,000,000 Gallons

Pueblo, Colo.
1,500,000 Gallons

"Wherever Water Flows STEEL PIPES IT BEST"

COUNT 'EM UP– AND SAVE!

Only STEEL FABRICATED PIPE has ductility and adaptability . . . plus all these economy advantages

1. Lower hauling or shipping costs.
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STEEL PLATE FABRICATORS ASSOCIATION

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STEEL PLATE FABRICATORS ASSOCIATION FOUNDED 1933

Visit NACE—Booth 114
Hotel Sherman, Chicago,
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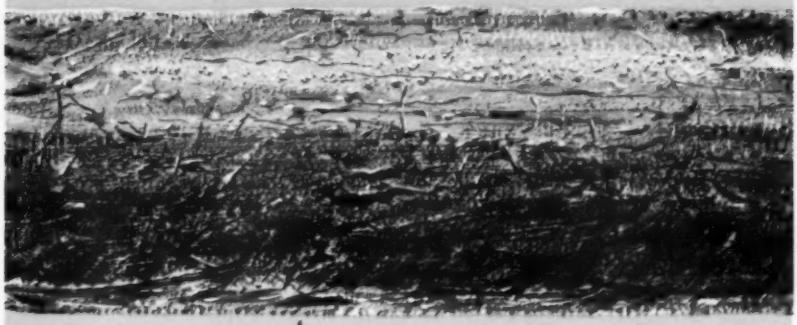

BROTHER-CAN YOU SPARE A LINE?

Can you afford to speculate with corrosion control?

Of course, you can't spare a line—even an inch of line! Conditions today are tighter than ever. **This means you can't afford to gamble with corrosion control.** Protective Coating Materials of the Plastics and Coal Chemicals Division give you time-tested pipeline protection. Superlative continuity, impermeability, bond, body strength, stability, and chemical inertness—from highest quality coal-tar pitch.

Proved and improved for three generations, our Pipeline Primers, Enamels, and auxiliary Protective Pipeline Felts, form a lasting barrier against corrosive elements. A staff of Field Service experts are at your call to offer you technical assistance that can save you maintenance time and costs.

Always ask your mill or field applicator to use our time proved Protective Coating Materials. Write for full information.

PLASTICS AND COAL CHEMICALS DIVISION
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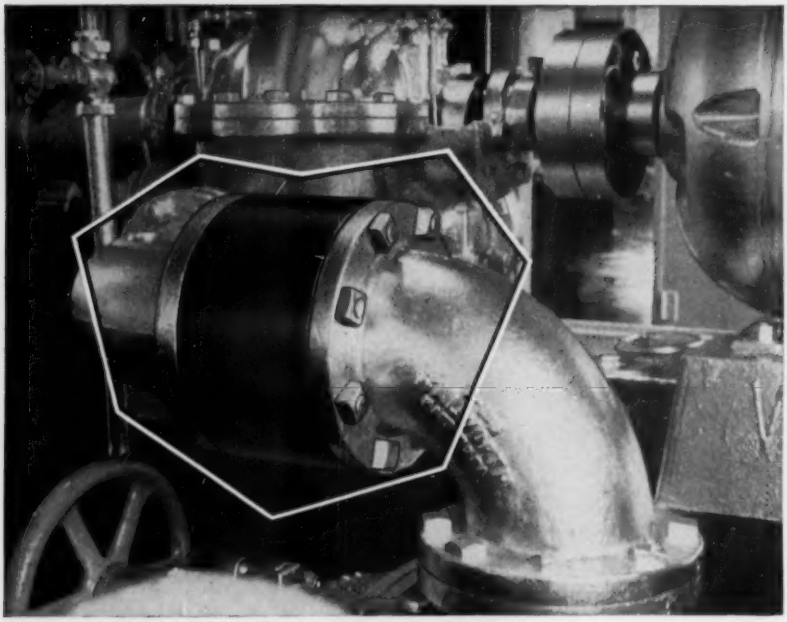
Allied Chemical



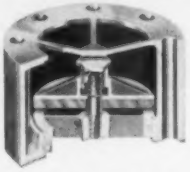
ELIMINATE BACK-DROP, SURGE AND HAMMER

When CPV silent, non-slam check valves are installed on the discharge of centrifugal pumps, the whole system is protected against waste and harmful surges. The need for expensive air cushions and other anti-hammer devices is eliminated.

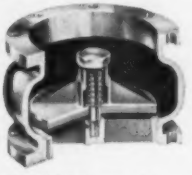
Spring-actuated, CPV check valves close automatically as soon as flow ceases. Back travel, which can be so damaging, is not required for closing.

Users report CPV valves easy to install and require no maintenance. Unique design includes bearing guides on both sides of disc and a full flow area in excess of pipe area. The valve operates in any position.

For complete specifications and prices write Combination Pump Valve Company, 853 Preston Street, Philadelphia 4, Pa.



STYLE "G"—2 to 10"



STYLE "GB"—6" and up

CPV SILENT NON-SLAM CHECK VALVES

Armco Welded Steel Pipe installed in pipe gallery of El Placer Water Purification Plant, Quito, Ecuador.

Designers and Constructors: Harold T. Smith, International, S. A.

Armco Pipe and Welded Steel Fittings in Quito, Ecuador, Purification Plant

Quito, Ecuador's El Placer Purification Plant is one of the newest and most modern in South America. It serves a city of 225,000 persons with its daily capacity of 14.5 million gallons.

All piping in the pipe gallery of this plant is Armco Welded Steel Pipe with a coal-tar enamel lining. Fittings were fabricated from Armco Pipe by local welders.

You, too, will find that Armco Pipe offers the economical, efficient solution to water treatment and transmission problems. Diameters range from 6 to 36 inches; wall thicknesses from 9/64- to ½-inch. Linings and coatings are to AWWA Standard C-203.

Write us for the free descriptive folder, "Armco Steel Pipe Delivers All the Water You Pump." Armco Drainage & Metal Products, Inc., 5649 Curtis Street, Middletown, Ohio. In Canada: write Guelph, Ontario.

ARMCO DRAINAGE & METAL PRODUCTS

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pH Meter Mod. 115

A full-fledged line-operated pH Meter of remarkable accuracy and stability at the low price of

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- SIMPLE IN OPERATION AND MAINTENANCE
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Write for Bulletin #225, also for literature on other Line-Operated and Battery-Operated Photovolt pH Meters

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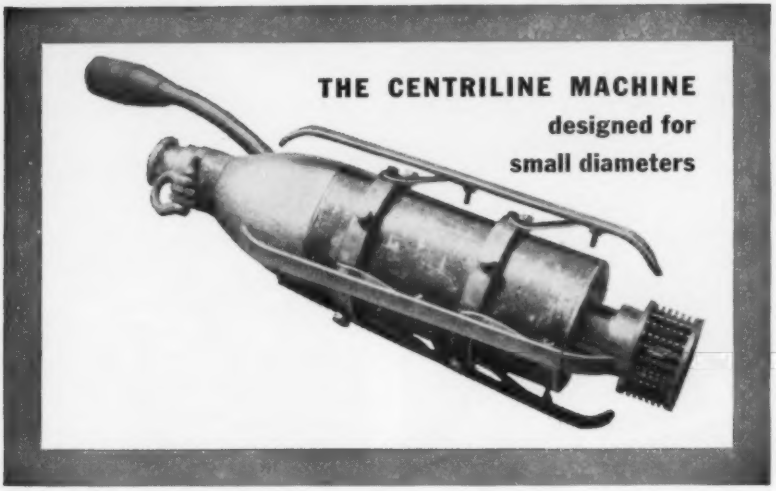
Also: Multiplier Photometers, Exposure Photometers for Photomicrography, Hemoglobinometers, Glossmeters, Polarimeters, Foot-Candle Meters, Interference Filters, Mirror Monochromators

NOW! THE CENTRILINE PROCESS is available for 6" to 14" mains, too!



Yes, your city's small but important transmission and distribution lines can also regain their original flow capacity and pressure through the universally accepted Centriline Process of centrifugally applying a cement-mortar coating to the pipe walls. If some of your lines inadequately serve your customers' requirements, including higher demands for fire protection, investigate the numerous advantages of Centrilining your mains now.

The new, small diameter Centriline Machine eliminates most excavations at valves, laterals and corporation cocks. By eliminating these fixed costs, lengthening the distances between access openings and permitting faster lining speeds, the new Centriline Machine has really reduced the cost of lining small mains. So much so, in fact, that every water works operator should reevaluate the economics of small pipe rehabilitation.

Send today for your copy of our illustrated booklet which fully describes how Centriline can help you salvage worn out pipes from 6" to 144" in diameter permanently and for much less than you would imagine.

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Branch Offices in Principal Cities of the United States, Canada and Latin America.

From Fort Ethan Allen, Vt. to Patrick Air Force Base, Fla.

Military installations join the trend to the modern pipe — "K&M" Asbestos-Cement Pressure Pipe with FLUID-TITE Coupling.

Steady, dependable water service— that's a major reason for the trend to "K&M" Asbestos-Cement Pressure Pipe. Once it's installed, you can forget about it. Year after year, the water keeps flowing through . . . clear and unimpeded by tuberculation, corrosion, or electrolysis. The combination of asbestos fibers and portland cement provides a rock-like durability.

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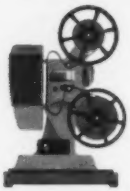

See the new "K&M" film, "Lifelines of Your Community." It's the exciting, dramatic story of "K&M" Asbestos-Cement Pressure Pipe from manufacturing to installation. Learn how your community can enjoy the finest water service . . . uninterrupted . . . at lowest cost. How you can rid yourself of costly, time-consuming repairs and replacement.

"Lifelines of Your Community" is now available for council meetings, engineer or waterworks association meetings, or to other interested groups. Write to us. We'll make arrangements for showing the film . . . and give you complete information on "K&M" Asbestos-Cement Pressure Pipe.

For Simplicity of Installation, Operation and Maintenance, SPECIFY . . .

CAN BE MOUNTED AS A MANHOLE METER OR WELDED SADDLE

The rugged, dependable Sparling 906 represents a new concept for meter installations. The 906 meterhead assembly is mounted directly on a standard AWWA flanged "T" or flanged manhole outlet for immediate operation . . . as a Welded Saddle Meter, it's furnished with a fabricated saddle permitting the meter to be mounted easily on an existing steel pipe. Sizes 16 to 72 inches.

OTHER OFFICES:

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Yes! ☐ We are interested in increasing our metering efficiency. Send us more information . . . no obligation, of course.

☐ Also send information on Sparling's line of Water Control Equipment.

Name .....

Company .....

Address .....

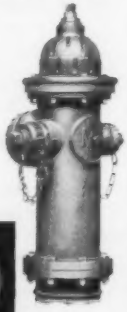
City ..... Zone ..... State .....

Send to: Sparling Meter Company
225 N. Temple City Blvd.
El Monte, California

To appease the GOD OF FIRE

Vulcan was the Roman God of Fire and each year on August 23 Roman families threw fish into a fire as a sacrifice to appease his anger. From the earliest dawn of civilization, fire has been to Man both friend and foe. In modern times, municipal fire fighting has long been a matter of an efficient fire department and an adequate water supply. This is where the water works man enters the picture.

On water depends the safety of human life and property—and lower fire insurance rates. The first fire-engine pump mentioned in history was used in Egypt in 200 B. C. Great and marvelous improvements in fire fighting equipment have been made in the past 22 hundred years. But all such equipment would be useless without water. A modern fire department in action is a spectacular performance. But it is the water works man "behind the scenes" who makes it possible. Give him some of the credit.

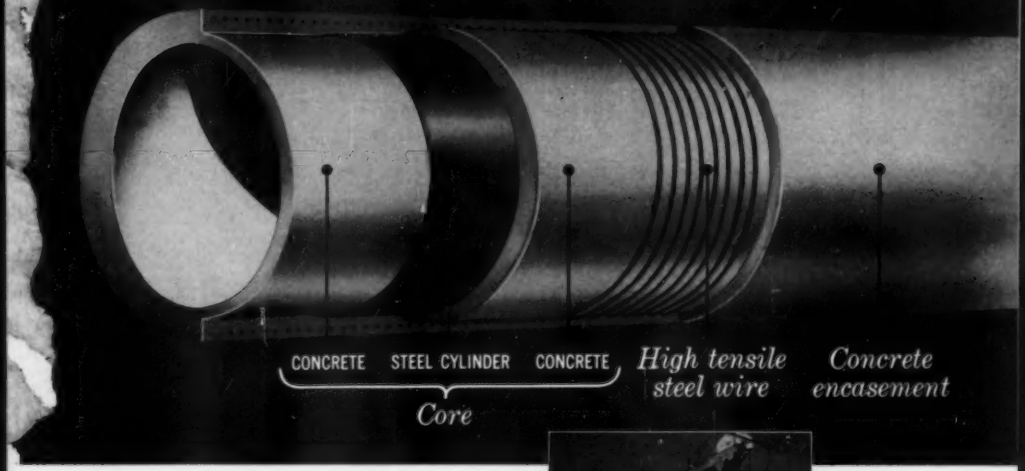


This Series is an attempt to put into words some appreciation of the water works men of the United States.

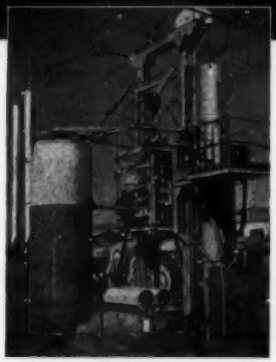
M&H VALVE
AND FITTINGS COMPANY
ANNISTON, ALABAMA
SUBSIDIARY OF WALWORTH

PRESTRESSED
CONCRETE CYLINDER PIPE
(Embedded Cylinder Type)

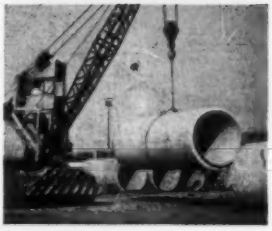
with Rubber Gasket Joint



All of the good qualities and characteristics desired by water works engineers for permanent water supply and transmission lines are embodied in this prestressed pipe of advanced design: great strength, sustained high carrying capacity, trouble-free service, and unusually long life. Prestressed pipe of this type can be designed more accurately, predictably and economically for most all conditions of internal pressure and external loads than any other type of high quality concrete pressure pipe. It is the finest quality pipe available in medium and large diameters for pressures generally ranging from 100 psi upward. American is currently undertaking the manufacture of this pipe designed for pressures ranging from 275 to 550 ft. of head for a portion of the U.S. Bureau of Reclamation Project being constructed for the Ventura River Municipal Water District. This Ventura River Project will serve 32 square miles of mountainous country with water for irrigation, municipal and industrial use in main and coastal reaches of Ventura County, California. When planning *your* future water "growth lines," look to American's quality pipe line products, extensive production facilities and half century of experience.



Prestressing machine wraps high tensile steel wire under carefully measured tension around pipe core.



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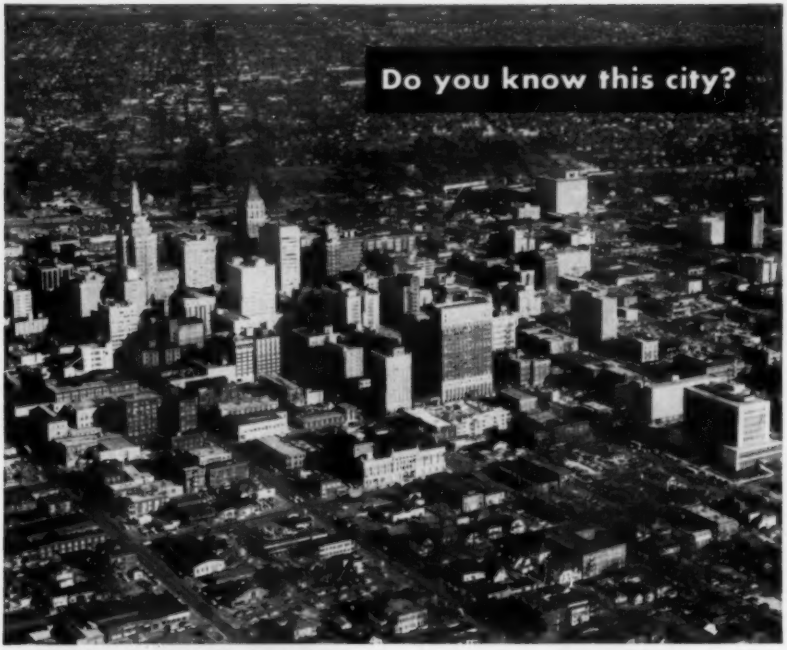

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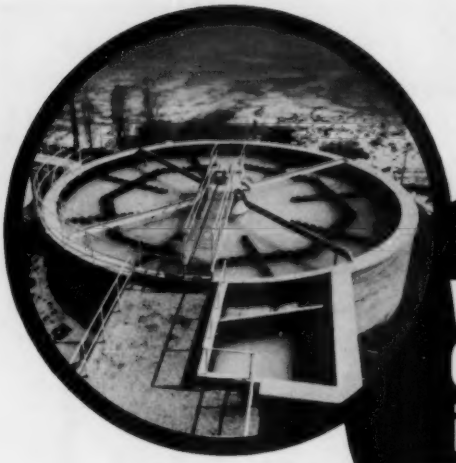

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Public Relations for a Modern Utility

John W. McFarland

A paper presented on Oct. 30, 1958, at the California Section Meeting, Los Angeles, by John W. McFarland, Gen. Mgr., East Bay Municipal Utility District, Oakland, Calif.

THE term public utility is almost synonymous with the term public relations. No utility management can choose whether or not it will have public relations; it can only decide how good it wants its public relations to be. Really good public relations cannot be easily realized, because it is not an easy job. It takes determination, thought, and a lot of work on the part of a lot of people to achieve good public relations. Everyone in the public utility field can do much to determine at what point in the wide range between bad and good public relations his own operation will fall.

The author remembers a remark made at a meeting of the California Section several years ago by Philip F. Walsh, vice-president of the Southern California Water Co., Los Angeles; it was, in effect, "Good public relations can be achieved primarily by rendering good service." There is no doubt about the truth of this statement. Certainly, a good public relations program for any business, particularly a public utility, must be based upon rendering good service. The best public relations program would probably fail if the service of a utility were inadequate. Even with a high level of service, however, because of the many complications and ramifications of running a modern, up-to-date business, there are many ways in which the effect of good service can be implemented in order to achieve the highest level of public relations. This is probably just another way of saying that good service in itself will not receive all of the recognition that it deserves. The author agrees with Philip F. Walsh when he said that good service is essential to good public relations, but wishes to add to this that management can profit greatly by a full exploration of the entire problem of making good service really pay off.

Customer Reactions

Most utility managements will hear from the customers in the event of ex-

ceptionally good or bad service. A letter of criticism received at the author's office reads:

It is apparent that a new low in public relations has been established by the EBMUD [East Bay Municipal Utility District] in connection with the increase in pressure in a certain area of the distribution system. This is not just my own opinion but is that of a considerable number of people who have expressed themselves in no uncertain terms.

Some of the questions which have been raised are as follows:

1. Why was the notice of the proposed increase in pressure hung on the doorknobs where such matter is frequently ignored?
2. Why was there no explanation of the necessity for the change?
3. Why was there no explanation of the difficulties which might arise?
4. Why was it left to each householder to determine whether or not it was advisable to consult a plumber?
5. Why could not pressure regulators have been installed?

I trust that this communication may receive your personal attention and not be sidetracked by some subordinate who is assigned the duty of opening your mail.

Another letter of criticism read:

The following circumstances are herewith reported for your individual attention.

First, that you may have a better understanding, let me state that when up and about I normally wear a hearing aid and, further, am at the present under the care of a physician under whose orders I am given a medium sedative every night at bedtime.

Last night we retired as usual about 10 PM after my sedation and laying aside the hearing aid. Some time shortly after 11 PM the hot-water tank safety valve lifted with sufficient force to waken us both, with severe rattling throughout the water piping of the whole house. Inspection showed the exhaust pipe from the valve flowing full and the gas flame, in response to the induction of cold water, also running full. After several unsuccessful attempts to reach listed numbers in the phone book I was connected with your office and a very surly operator, who interrupted my explanation about halfway with: "Nothing can be done tonight, call in the morning," to which I replied: "This is an emergency. What shall I do?" The reply was: "Shut off the main valve in front of your house." At this point I lost my temper, which for my own physical good is not the best. For this I am duly penitent and apologize profusely.

Finally in desperation I stated the situation to the police, asking for advice. They switched me to the Fire Department, who immediately dispatched the nearest truck, the man in charge of which carefully inspected the installation, shut off the water and the gas, and advised me that there was absolutely nothing wrong with the installation, the condition being caused by excess pressure. . . .

In view of all the circumstances, I wish to advise you:

1. I request you install a suitable pressure control valve at the proper point in your distribution system.
2. Knowing that No. 1 will not be complied with, I wish to advise you that any damage to my water installation or property will be entirely your responsibility.

Customers also write to compliment a utility when they receive good service from it. One such message to the East Bay Municipal Utility District (EBMUD) read:

Too few persons ever take time out to voice their appreciation of your fine service and product.

Having just returned from a visit to Chicago, I can sincerely say that the quality of our water is one of the many things which make our glorious state and community a more desirable place in which to live.

Another complimentary message received by the author's office read:

A crew of your men have just finished installing a new line over my property.

I feel I would be very remiss if I failed to express to you my appreciation of the courtesy and helpfulness of all of the men engaged in the work. Everything possible was done to avoid inconveniencing us from the start to the finish of the work. I hope you will be kind enough to pass along this commendation.

All utility managers would like to receive more of the latter type of letter than the former. A utility's mail will probably never include more letters of commendation than letters of complaint. All utility managers, however, can do many things to reduce the volume of complaints and, equally important, each utility can put itself in a position where the handling of complaints is easier because of a conditioned and more sympathetic public.

The discussion of good public relations in this article is basically a recitation of the thinking and program of the EBMUD in this field. All utility managers are naturally most familiar with their own operations. In this case, the author feels that the EBMUD program is thoroughly based upon sound, accepted practice of the best techniques in the field, and therefore it represents what one organization is doing to follow a good and recognized program. For that reason the EBMUD program should serve as an acceptable case history for any utility manager who wishes to concentrate on the problem.

The EBMUD program is based on several major foundations:

1. A corporate personality
2. Employee public relations
3. Communication with the public
4. Special techniques.

Corporate Personality

An ideal objective would be achieved if a utility could establish in the minds of all of its customers an image of an organization that is both efficient and friendly. To achieve this requires a great deal of advance planning and effort. A vast segment of the public hardly recognizes the existence of the utilities serving it. All too often the first sharp realization of a water utility's existence comes during a crisis of some kind during which the corporate image established is quite likely to be an unpleasant one. When a crisis develops, it is too late to think about good public relations. If good public relations have been established in advance, then quite often a crisis can be worked out with a minimum of unpleasant reaction. Therefore, it is important to build a corporate personality as an image in the public's mind. The "man in the street" must gain the impression that the utility is a group of people serving him, and not just steel and concrete installations. This image of a definite personality must be implanted in the public mind to assure understanding, cooperation, and support, both in good times and in times of stress. All effort should be directed toward an image of the utility as: [1] the distributor of a safe, superior product at the lowest possible cost and under conditions of prompt service; [2] a reliable custodian of public funds, responsible to and owned by the customer, and directed by an efficient, public-spirited management; and [3] an integral unit of the community to be regarded as neighborly, approachable, and conscious of human values as well as dollars, and making a positive contribution to the community's economy, health, safety, and welfare.

There are several ways in which this corporate image can be established:

1. *Courtesy.* Courtesy practiced at every point of contact is one of the most effective methods of personalizing an organization. All employees, through the media of memoranda and conferences, should be encouraged to make courtesy a way of life.

2. *Participation.* Participation in community organizations will develop recognition in all phases of civic life. Employees should be encouraged to

participate individually and the organization itself should participate wherever possible in key community activities.

3. *Public speaking.* Public speaking engagements should be encouraged in order to reach broad cross-sections of the public. Members of a water utility organization are always in demand to help fill out the programs of many organizations and service clubs.

4. *Personal letters.* Personal letters of congratulation to public officials, and to any individuals rendering special service to the community, are always flattering and well received.

5. *Publicity.* Advertising, forms, letters, structures, signs, and architecture should be designed to establish a definite favorable corporate personality.

Employee Public Relations

The importance of employees in a public relations program is not a new development. This phase of public relations has not received very much attention, however, and examining it might give a utility management a more compelling motivation in the fields of both employee relations and public relations.

All utility personnel in management positions recognize the importance of good employee relations. Management is continually trying to discover methods of improved employee relations and countless approaches have been made in this field. While reading in this general field some time ago the author encountered a thought-provoking theory: employee relations thrive best in a community where public relations are good. In other words, people like to work for an organization that is well thought of and well spoken of in the community and, conversely, do not like to work for an organization that is in general disrepute. This makes good sense and points toward a program that is in many ways more tangible than some of the results of other employee relations and public relations research. It has a double appeal: if improved public relations will improve employee relations and if through its employees management can improve public relations, then it would appear that management might be able to develop a truly reciprocal movement in which the beneficial results should be greater than the effort expended. Therefore, it behooves management to consider its employees as one of the most important tools for improving public relations.

Too many utility managers fall into the error of "letting George do it" in the field of public relations. If a problem exists someone is assigned to deal with it, or, in larger organizations, a public relations director is appointed. The management then expects its problems to be solved automatically. No arrangement will fail sooner than this. One man, regardless of his ability, cannot singlehandedly solve the public relations problems that beset a public utility. The real answer is to implement the work of the public relations man by enlisting the cooperation of all of the other employees in the organization. If this is done management will also gain further implementation through these employees' families and friends. In this way the public relations director can find himself in possession of a veritable army to help work out his problem.

In order to enlist their wholesale cooperation employees must be kept informed about major utility problems so that they in turn can help keep the public informed. Keeping people informed is particularly difficult in the field of public relations because of cer-

tain mistaken concepts. Good public relations does not mean (as many would wish) that customers' wishes can always be granted and that everyone can always be made happy. A utility cannot always say "yes" to the customer; more often than not it must say "no." This does not mean, however, that good public relations are impossible. People are instinctively suspicious of something they do not understand. If people can be informed—whether the news is good or bad—a big segment of the public relations battle can be won.

Recently the author heard the public relations director of a large railroad company illustrate this point. One of the worst problems in railroad operation is the terrible public reaction that occurs when there is a bad train wreck. In this public relations director's company the practice had usually been to do everything possible to prevent publicity when a wreck occurred. This did not improve public relations. This company then tried a new technique: immediately after any disaster all of the facts were made known to the public. It is reported that the result was miraculous. With this approach the bad news was over with quickly and there was nothing more to talk about. The management could then proceed to settle its difficulties without the harrowing accompaniment of public criticism.

The implementation of a public relations program through employees of a utility can be carried out through the following steps:

1. Management must be completely devoted to the program. A management public relations committee can be helpful. It is important that the entire organization be made to realize how strongly management feels on this subject and organizing a management committee can achieve this.

2. The plan and objectives of the public relations program must be made known to the widest possible group of employees, especially those who contact the public in their daily work. This can best be done through supervisory channels by holding employee-management conferences.

3. Employees should be specifically trained in certain fundamental courtesies of business conduct, such as: correct use of the telephone, writing neat and courteous business letters, making appointments when it is desirable and keeping them, handling complaints promptly and helpfully, and making difficult collections in as tactful and considerate a fashion as possible.

4. Employees should be familiar to the greatest extent possible with the reasons behind policy and procedure. Referral to rules and regulations is not sufficient to support a position unless the reasons for such rules can be explained clearly.

5. Employees should be informed promptly of changes in policy. The position of the employee as a public relations ambassador is greatly weakened if he does not learn of a change until after it is publicly known.

6. Employees should be encouraged to participate in community affairs, and social, church, and fraternal activities. (This is also directly related to building a corporate personality.) Such participation yields real benefits to the individual and the organization is also benefited. Frequently these contacts are the only direct contact between the utility organization and a customer. In this process the employee is able to sample public reaction directly and he may get more directly to the roots of opinion than a public opinion poll can.

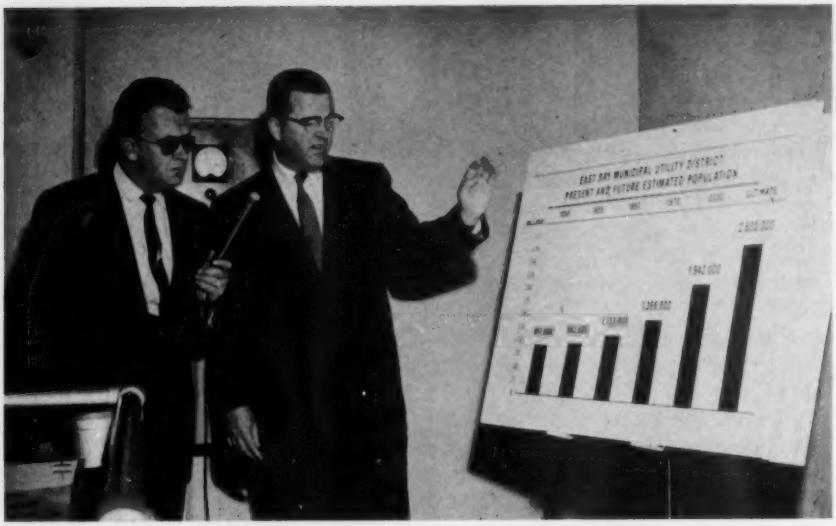

Fig. 1. Television

A scene from the television program "Success Story," sponsored by Richfield Oil Corp., Los Angeles. The author (right) is explaining a population forecast and its relationship to future water needs.

Fig. 2. Truck Posters

Truck posters are displayed on EBMUD equipment. More than 100 posters of this type are used in each 60-day period.

Communication

A positive, two-way system of communication between a utility and its customers is one of the fundamentals of any comprehensive public relations program. It must accomplish two principal objectives: establish understanding between the utility and its public and intercept criticisms of utility operation and act as a sounding board for suggestions for improving service.

A standard communication approach includes many continuing functions. Very good results have been obtained by the EBMUD from investment in these functions in the past and new techniques can be applied wherever feasible to make them effective in the future.

1. *Press, radio, and television.* Personal contacts with representatives of the press, radio, and television should be scheduled at least once a month. Even though no actual news stories result directly these personal contacts will be extremely important if it is necessary to ask the cooperation of these media. Press releases, in particular, are useful. They are almost always accepted by the various newspapers if they are written and submitted in such a way that they require little or no rewriting. As an example of what may be achieved by cooperation with mass communications media, the EBMUD a short time ago was featured on the "Success Story" television program of the Richfield Oil Corporation, Los Angeles (Fig. 1). Some people in the utility field may have felt in the past that water was a subject which would not attract much public attention. As finally presented, and with the proper direction and technique, the program turned out to be one of the most interesting of the series.

2. *Photographs.* A complete file of photographs should be maintained, reflecting the growth of the system.

3. *Truck posters.* Every 60 days large posters are placed on service equipment in the EBMUD area (Fig. 2). These posters always carry a message related in some way to the subject of water.

4. *Facility tours.* Conducted tours of filter plants, pumping plants, reservoirs, power plants, and other facilities are extremely helpful in getting a message across to the public. There is no substitute for actually seeing the facilities.

5. *Annual reports.* An annual report is an accepted medium of communication for all public utilities. Much can be accomplished if the annual report is designed as a public relations brochure rather than an exhaustive compilation of statistics and facts incomprehensible to the average layman. The annual report presents an opportunity to use the latest journalistic techniques in the same way that private, competitive business would use them.

6. *Bill inserts.* The most inexpensive way of getting any single thought across to the greatest number of customers is to include a message with the regular bill. The EBMUD calls these "bill inserts." Every 60 days a new subject is, with the aid of a commercial artist, placed before each one of the district's customers. These are constant reminders of the efforts of the EBMUD to do a good job for the public. As a result of research management has concluded that the customers will react very favorably to

more details about EBMUD personnel as well as operations.

7. School program. School children are the utility's future customers and school children are always hungry for knowledge. The EBMUD conducts a constant program to make facts about the water system available through talks, motion pictures, and conducted tours. Often a short quiz or test is given after the "course." On many occasions management has found that material submitted by students after these "courses" can be used by the district as a tool of further improved communications.

8. *General literature.* The EBMUD has developed and is keeping up to date several types of pamphlets and forms which are always kept on hand for distribution. It is surprising how often it is helpful and beneficial to be able to produce such a pamphlet for an individual or a group asking questions. Such literature may not only answer specific questions but also open new and broader fields.

In addition to the standard approaches to communication, there are also a few special approaches which deserve considerable attention. They are probably not quite so commonly accepted nor put into practice so often as the standard approaches. They can, however, be valuable, particularly for the larger utilities, although any utility should be able to profit by some application of them.

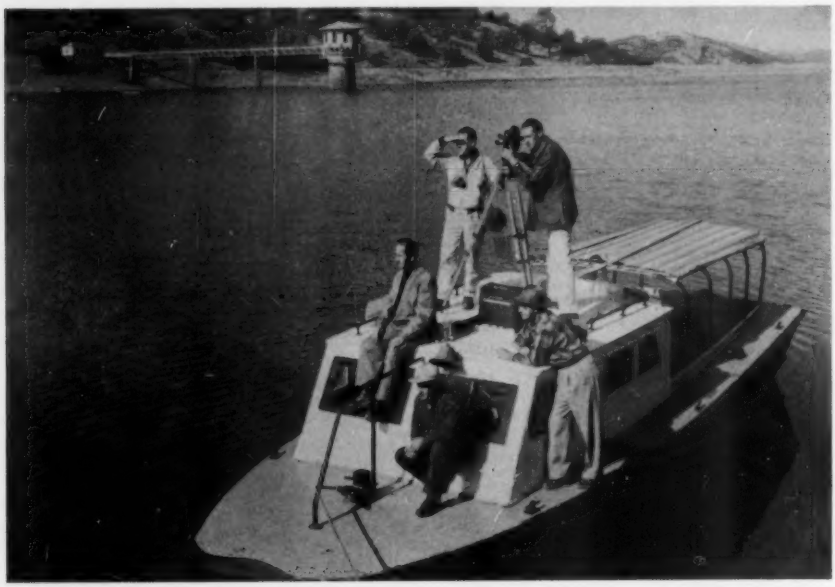

Fig. 3. Motion Pictures

A production crew on location at Pardee Reservoir, in the EBMUD. They are shooting scenes for new EBMUD sound-color film, "Taproots to the Living Waters."

1. *Press conference.* The press conference technique offers the possibility of a well calculated release to all members of the press of desired items of information. Of course, it must be kept in mind that such exposure through the press conference also entails the hazard of running a gauntlet of questions. Representatives of the press can be most persistent and most probing. Therefore, before adopting the press conference method a utility manager must be prepared for everything that goes with it in a free exchange of questions and answers. It is certain that the press appreciates the opportunity to receive news and background information first-hand and often responds with more space than it might otherwise allot.

2. *Governmental contacts.* Carefully developed lines of communication at all levels of government, both local and state, should be established and maintained. A regular schedule is necessary in this and it must be diligently followed. It is impossible to expect the closest cooperation from governmental officials if the only time the utility manager sees them is when a permit is required, a change in zoning is necessary, or some other favor is to be requested. Personal contacts with elected officials and administrative department heads at all levels should, therefore, be established. One good idea might be to have an annual conference for the mayors, councilmen, and administrative department heads from each political subdivision within a utility's area. Three principal objectives could be realized by such conferences: [1] closer personal ties could be maintained; [2] areas of understanding about questions expected to be facing the utility in future years could be developed and the cooperation from public officials which will be needed to solve them might be guaranteed; [3] advantage could be taken of the suggestions and criticisms these officials could make regarding improvements in service and public relations.

3. *Display advertising.* Advertising represents one of the most direct and effective methods of reaching the public. It is probably the only method which can be kept entirely within the absolute control of the organization that uses it. In addition to this, it is probably the cheapest way *per capita* of reaching the entire customer-public. In the field of management, advertising is one of the basic techniques of public relations. There are many who maintain that a public utility's program cannot be fully effective without the use of advertising. The opponents of advertising in the utility field argue that it is not warranted as an expense because most public utilities are not competitive but "monopolistic." The author feels that this is a short-sighted criticism. Most water utilities may not be in competition with another similar business but they are continually in competition with a standard of performance. Further, other techniques of public relations cost money too and are, in effect, a way of advertising. Advertising as such, because its expense can be pinpointed and because it is so closely associated with retail competition, has been subject to unwarranted criticism in the public utility field.

4. *Public opinion poll.* All public utility managers, whether or not they have a public relations program, are at many times curious as to the opinion the public has about their work. This is particularly true when a utility executive has a proposed project in mind and would like to forecast the public's

reaction to it. Even a water utility manager who is an expert in his field might discover that he is guessing on the basis of false assumptions in trying to predict public reaction. A fairly reliable way of determining public attitude is through the use of the public opinion poll. Polling techniques have been developed scientifically and can be relied upon for a fair degree of accuracy. They are accepted by many businessmen and politicians. Good polling techniques need not be too expensive. It has been the experience of the EBMUD that they are well worth the thought, money, and time they cost.

Special Techniques

In addition to the items already discussed there are a number of other activities available in the public relations field. These other activities might be called "special techniques." A few of these, which the management of the EBMUD has put into effect or considered, are:

Fig. 4. Open-House Events

In ceremonies opening the new EBMUD Oakland, Calif., business office with a "drive-in" window for bill paying, civic, business, and chamber of commerce officials took part with EBMUD officials.

1. *Motion pictures.* The EBMUD has produced several sound-color motion pictures (Fig. 3). They are planned to create in the mind of the viewer an appreciation of the vital part which the district is playing in the growing economy of the area. The pictures are in great demand before

organized groups. The development and production of these motion pictures are continually progressing. Unless new ones are produced every so often, this program would soon appear dated.

2. *Open-house events.* Appropriate ceremonies can be held marking the completion of major facilities of a utility (Fig. 4). These open-house programs should be staged for the public, the press, and the employees of the utility.

3. *Special communications.* Many utility projects, particularly pipelaying jobs, can cause great public inconvenience. In order to minimize inconvenience and complaints it is worthwhile to devise special programs to inform the affected public, each one organized to suit the circumstances. Special communications may take many forms —a letter to the neighborhood, or a series of signboards, for example. In extreme cases special communication may even mean personal calls by district representatives upon affected people. Special communications of any type will require flexibility, mobility, and consciousness of the need in order to be effective as an item of special attention.

4. *Uniforms.* Appropriate uniforms for personnel is a frequently debated recommendation. Most critics of uniforms claim that employees resent being uniformed in their jobs. There is no doubt, however, that for some functions, such as meter reading, some advantage can be gained by having uniformly appareled representatives. For a great number of customers, the meter reader is the only personal contact with the utility. It should, therefore, be a contact that will be pleasant and leave in the mind of the customer a favorable picture of the utility represented. The EBMUD has also provided uniforms for its watershed patrolmen. In the opinion of the author these uniforms have done much to encourage public acceptance and also have helped build employee morale.

These four do not exhaust the list of "special techniques." Any utility manager may develop others, suited to his needs.

Methods of Collecting Delinquent Water Accounts in Ohio

Ralph S. Locher

A paper presented on Sep. 19, 1958, at the Ohio Section Meeting, Cleveland, Ohio, by Ralph S. Locher, City Director of Law, Cleveland, Ohio.

SUPPLYING water to the public is not a service that has attracted a large degree of private investment. It is, therefore, chiefly left to governmental agencies to perform, as a proprietary function of government. The collection of delinquent accounts by municipally owned water utilities has features which distinguish it from collection by a privately owned utility. It is sufficient to note that a privately owned utility can only collect delinquent accounts by means of a water shutoff or a civil suit. This article will discuss methods of collection open to a municipally owned water utility.

Shutoff and Civil Suit

In Ohio the authority for municipalities to engage in water utility services derives from a direct grant of power by the state constitution (*1*). The power granted by the constitution to operate public utilities has been declared by the Supreme Court of Ohio to be self-executing and beyond the scope of the state legislature to alter (*2*).

The general statutes of Ohio nevertheless reiterate this power. For water utilities the pertinent statute is contained in Sec. 743.01 and 743.02, Revised Code. There is no doubt that the authority to shut off water as a means of collection of delinquent accounts is included both in the constitutional grant and in the statutory authority to conduct a water utility (*2, 3*). An ordinance or regulation providing for shutoff is, however, essential to make this authority effective.

Another method of recovering the arrearages in accounts is the civil suit. Proceeding by civil suit is not effectual, however, because of the small amounts usually involved and the difficulty of locating many delinquent accountants who have established new residences.

Responsibility of Landowner

The inefficacy of civil suit and the fact that shutting off water supply does not prevent a delinquent accountant from moving if he is the tenant and not the landlord has led to a concentration on the landowner as the person from whom the utility should collect delinquent water bills. This concentration is what led to the case of *Pfau* v. *Cincinnati* (*2*) in which the Supreme Court of Ohio ruled that an ordinance making the landlord or landowner liable for the water charges was a valid exercise of the self-executing powers granted by the state constitution (*1*).

This ruling obviates the necessity of multitudinous petty civil suits, and,

because real estate cannot move and a tenant can, it also makes the shutoff more effective. But this does not entirely relieve the utility fiscal officer from troublesome delinquent accounts. There is the problem of real estate which has changed ownership while its prior owner had a delinquent water account. In this situation the problem is more difficult. In a recent case a court ruled that a subsequent owner of property could not be held responsible for the arrearages of a prior owner, unless a lien had been authorized and perfected (*4*). This appears to be the view of the overwhelming majority of courts throughout the United States.

The methods of collecting delinquent accounts should include some way to avoid loss due to transfer of title to real estate. An obvious way to accomplish this is to permit a utility to perfect a lien on real property for unpaid water charges. Except, perhaps, for certain common-law liens the only valid liens in Ohio are those authorized by state statute. The state legislature is, therefore, the only agency which can authorize a lien. Even under the home rule powers granted by the state constitution a municipality—probably—cannot create a lien by ordinance or otherwise. The author believes that the legislature intended to authorize a lien for water charges when it adopted laws presently on the books; but as a result of its failure to be more specific in its enactments relating to this matter, the Supreme Court of Ohio has denied an attempt by a city to place a lien for water charges (*5*).

Notwithstanding that the court denied a *city* this right, a state statute (Sec. 735.29, R.C.) permits a *village* to certify delinquent water charges to the county auditor to be collected as other village taxes are. Another state statute (Sec. 729.49, R.C.) provides that sewage charges may be constituted a lien upon property and collected with the municipal taxes. Sewage charges are usually based on water consumption and collected with water bills. It would, therefore, appear to be consistent to permit a lien for water charges as well as sewage charges.

Legislative Efforts

The law department of the city of Cleveland prepared and had introduced in the 1957 session of the state legislature House Bill 828 to amend Sec. 743.04, R.C. so that it would provide for a lien for water charges. This bill unfortunately was defeated—but only by two votes. The department intends to introduce this bill again in the 1959 session (the Ohio legislature meets only in odd years). If, under the present law, villages may collect water charges by the same methods as other village taxes, and if villages and cities can collect sewage charges as a lien, the author feels that there is no reason why the statutes should not be consistent and also include water charges as liens against real property. The only really effective solution to the problem of collecting delinquent water accounts is to permit a utility to perfect a lien for water charges.

The author understands that title companies were opposed to H.B. 828 because of its possible title search effects and that county auditors were opposed because delinquent water charges could then be collected with the tax billings, thus complicating auditing procedures. Opposition on such grounds as these appears to the author to be unwarranted. Sewage charges have for many years been collectible as liens without involving any undue hardship. It must also be remembered

that delinquent accounts are the exception and not the rule. If these points, and others, are stressed the author feels sure that the Ohio legislature will pass a suitable measure at its 1959 session.

Recommendations

The department of a utility which bills charges should be set up so that it can keep abreast of delinquencies and prevent them from extending over long periods. Water service should be shut off before the unpaid bill becomes much larger than the average bill for a given billing period. Delinquent accounts become most troublesome when they are permitted to build up.

A delinquent account should be written off as a bad debt in cases where the accountant has absconded and cannot be readily located and the account has become stale. It is not worth 6 months of legal action and expenses of $500 to collect a $7 delinquent account. On the other hand, if the accounts are sizable and the delinquent accountant is readily traceable, civil suit should be instituted promptly.

City councils and administrative rule-making agencies should take advantage of the *Pfau* v. *Cincinnati* case (*2*) and adopt an ordinance or regulation making the landowner liable for water charges. In this way they will, short of the enforcement of a lien, be taking advantage of the law now available to them.

References

1. Constitution of Ohio, Art. XVIII, Sec. 4.
2. *Pfau* v. *City of Cincinnati*, 142 Ohio 101 (1943).
3. *Mansfield* v. *Humphreys*, 82 Ohio 232 (1910).
4. *Cohn* v. *Celebrezze et al.*, Court of Common Pleas, Cuyahoga County, Ohio, No. 685319 (1958).
5. *Hohly* v. *State ex rel.*, 128 Ohio 257 (1934).

Modernized Accounting Procedures for Water Utilities

F. Joseph Rachor

A paper presented on Sep. 17, 1958, at the Ohio Section Meeting, Cleveland, Ohio, by F. Joseph Rachor, Partner, Arthur Andersen & Co., Accountants & Auditors, Cleveland, Ohio.

PUBLIC realization of the importance of the services performed by water utilities has greatly increased. This emphasizes the need for prompt and efficient solutions of the problems created by the growth of the demand for these services.

These problems relate to all fields of a water utility's business: construction, operation, finance, rate-setting, and administration. A thorough knowledge of costs is essential in solving them. One of the primary objectives of accounting should be to furnish management with accurate, timely, and regular data for effective cost control. In the numerous cases where accounting and reporting systems have failed to meet this objective, utility managements have had the choice of meeting their problems with inadequate information or of taking steps to get adequate data. This article will cover some of the many things that accounting can and should do to aid the managements of both publicly and privately owned water utilities.

Purposes of Accounting Systems

Essential requirements, if an accounting system is to supply necessary information, are the proper matching of revenues with applicable expenses and the assignment of both to the proper month or year and the area served. Cash-basis accounting frequently fails in this objective. In this system revenues and expenses are recognized and accounted for only as the cash is actually received or paid. Costs incurred in rendering service may be paid in cash and charged to expense in one month while the payment for the service may be collected from the customer and credited to income in some later period. Equipment, materials, insurance, and many other expenses, may be charged to operations in the month they are paid for even though they will be useful or desirable in rendering service for months or years to come. Cost reports based on such practices are of doubtful value.

Substantially all privately owned utilities and many publicly owned utilities use accrual- rather than cash-basis accounting. An accrual basis assigns revenues and expenses to the periods to which they pertain, rather than the period when the cash is received or paid. The accrual basis is not complex and the author strongly recommends its adoption.

An accounting system should also be designed to maximize, insofar as is practical, the protection of the assets of the utility against misappropriations. A utility manager should not

be misled into thinking that a periodic audit by the state, or any other agency, is sufficient protection. Such audits are helpful but the primary safeguards must be incorporated in a utility's own internal procedures. One means to this end is to have receipt of revenue and the accounting of it handled by different authorities. Another is to separate disbursing authorities from both those in charge of accounting and those authorized to issue purchase orders or to approve invoices for payment. These are only examples; internal controls should be considered in connection with all procedures of a water utility's business.

Billing and Accounting

As the ultimate source of a water utility's revenue is customers, the subject of billing and accounting is of importance. Great progress has been made in mechanization of this activity, resulting in increased efficiency and internal control. In all but the smallest water utilities cumbersome, old-fashioned hand ledgers and clumsy, antique machines may well be obsolete. The most important point is that the machine and system should fit the particular needs of a utility. Many water utilities employ independent consultants to assist in evaluating proposed installations.

Other noteworthy items related to billing and accounting include:

1. Adoption of cycle billing to eliminate peak-work periods
2. Maintenance of meter or customer counts to insure that all customers are billed
3. Control of accounts receivable by personnel with no access to the detail customers' ledgers
4. Recording revenue as billed rather than as collected (there have been cases where *unbilled* accounts were recorded as collected)
5. Approval of all bill adjustments by supervisory personnel disassociated from the detail records
6. Eliminating discounts and penalties to save billing and adjustment time and also to promote goodwill
7. Establishing firm procedures for collection reminders and shutoff notices
8. Sending rounded-off estimated bills monthly, corrected for actual meter readings made quarterly or less frequently, to save billing and meter-reading time and conserve capital
9. Updating reconnection and other customer charges to reflect current costs.

There are other items not mentioned on this list. It is important to remember that billing and accounting practices should be reviewed periodically. Improvements are constantly being made which can lead to cost savings and increased efficiency in cost data and internal controls.

Records

Normally a utility has an investment in materials and supplies. Accounting and operating functions are both aided by maintaining a perpetual record of these items. A continuing stock-record system is important in internal control. It can also quickly furnish data as to whether needed quantities are on hand, when to reorder, prices of materials used, excess or obsolete stock, for usage reports, and other purposes. The record should be checked by periodic or cycle inventories. Issues of materials and supplies should only be made upon receipt of a properly approved requisition indicating the activity and area to be charged with the cost. Special proce-

dures may be installed to simplify the accounting for any items which are relatively minor in value.

Payroll is usually an important part of a utility's costs. A modernized payroll system and record should provide safeguards for funds, efficient methods of computation and distribution, proper accounting for payroll costs, and an efficient system of reporting them to the management. Modern payroll procedures also include: an authorization system for approvals of hiring, rate changes, and overtime; a time-reporting system so that charges are made to the proper activities and areas; and either mechanized or highly streamlined "one-write" procedures in preparing required records. Many utilities have payroll checks distributed from time to time by a person disassociated from all these procedures, in order to guard against making payments to people who are not actually working for the utility.

Accounting for transportation equipment usage and maintaining the necessary or desirable record of it begins with field reporting, which can be combined with labor-time reporting. Costs may be accumulated in a separate account and distributed to the activities and areas for which the vehicles are used. Cost records may be maintained for individual vehicles or for groups of vehicles, as desired. The information made available by such steps is also helpful in controlling use, considering repairs and replacements, weighing the desirability of leasing rather than purchasing, and other related management problems.

Continuing unit-property records show details of the cost, age, and nature of property owned or used by a utility in the conduct of its business. These records are commonly used in both publicly and privately owned utilities. They furnish information which is useful in both the operating and the financial side of the business when considering, among other things: rates, insurance coverage, claims, financing, depreciation studies, retirements, replacements, construction estimates, purchases, appraisals, and classifications of construction and maintenance. These records should be designed to obtain the desired data and to avoid the high costs that can be incurred if the project is not properly planned and controlled.

The forms and details of continuing property records may vary. The continuing property record of one publicly owned water utility is completely on punched cards and reports of the details of water property in its area are regularly made to each taxing district. The record of another publicly owned utility is posted by typewriter. Each system is excellent for its particular purposes.

Property accounting should also provide for work order procedures and proper authorization of jobs and the accumulation of charges in connection with them. Progress and status reports on construction and completion reports with explanations of variations from approved estimates should also be furnished.

Publicly owned utilities frequently record charges in lieu of taxes and also price and record free service to other governmental areas. These practices are helpful in measuring the true results of operations and in avoiding discrimination in rates.

Depreciation

In accounting the term depreciation expense is used to describe spreading the cost of items of value over the

period in which they perform a service. If a large pump is purchased in 1958 and is to be used for some years to come it would be improper to charge all of the cost of the pump to 1958 operations. This also applies to materials and supplies, payrolls, and contractors' charges in connection with construction that has value in periods after those in which the costs were incurred. Such costs should be charged against the customers, areas, and periods benefited. This is the purpose of depreciation provisions.

Depreciation is normally computed on the basis of the cost of the property, in terms of dollars spent in connection with it. Many now recognize that, because of inflation in the past and the expectation of more in the future, computation of depreciation on this basis does not recover the real value of the dollars invested. Although this problem is recognized not much action has been taken to solve it. A praiseworthy exception is one fair-sized, municipally owned utility which in 1957 began to provide an additional amount of depreciation to compensate for the decline in the value of the dollar, thus preserving its real capital. Another utility was recently allowed an additional amount for economic depreciation in the setting of service rates (*1*).

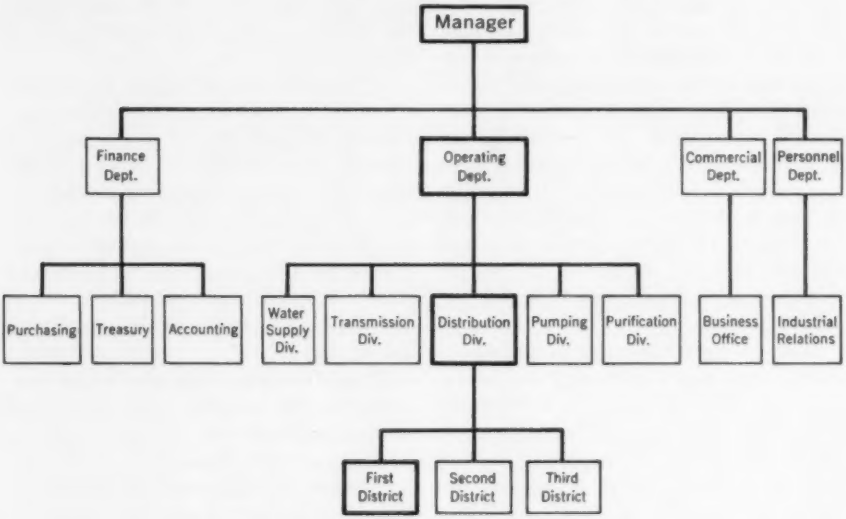

Fig. 1. Water Utility Organization Chart

Condensed organization chart of a representative water utility. The discussion in the text describes responsibility accounting in relation to the heavily outlined sections.

In some cases instead of providing for depreciation publicly owned utilities charge to expense amounts equal to currently due payments on their debt. This is better than no consideration of depreciation but it can result in discrimination between customers, areas, and periods of time. Debt maturities

are normally shorter than the lives of assets constructed with the proceeds of a loan.

Responsibility Accounting

To meet the needs of management there has been developed in recent years a system of accounting for both private and public utilities which provides reports organized on the basis of where the costs are incurred and who in the organization is responsible for their control. The system is tailored to each specific organization and results in reports prepared for each responsible supervisor to aid him in controlling the costs for which he is responsible. Management control is based upon these responsibility reports.

Figure 1 shows a simplified organization chart of a representative water utility. The detailed working of a responsibility accounting system will be described in relation to the Distribution Division of this utility, although any other division could have been chosen. In principle, the accounting system could also be applied in a util-

TABLE 1

Responsibility Statement—Distribution Division, First District

Breakdown	Actual Expenditure	Budget	Variation
Overhead			
Supervision	$ 982	$ 850	−$132
Distribution engineering	1,332	1,320	−12
General clerical expenses	1,550	1,460	−90
Other functions	105	200	+95
Subtotal	3,969	3,830	−139
Operation			
Inspecting distribution system	1,418	1,200	−218
Investigating water leaks	521	300	−221
Operating distribution system	859	920	+61
Operating distribution reservoirs	1,642	1,620	−22
Groundskeeping on rights of way	2,746	160	−2,586
Hydraulic tests and flow measurements	457	350	−107
Removing and resetting meters	1,723	1,650	−73
Services on customers' premises	821	650	−171
Other functions	572	360	−212
Subtotal	10,759	7,210	−3,549
Maintenance			
Maintaining exposed mains	1,040	580	−460
Transferring services to new mains	2,522	1,450	−1,072
Repairing equipment*	16,132	12,030	−4,102
Other functions	1,157	1,200	+43
Subtotal	20,851	15,260	−5,591
Total	$35,579	$26,300	−$9,279

* For this table repairing was condensed into one item. In the original responsibility statement repairing was subdivided as follows: main regulators, cast-iron mains, asbestos-cement mains, other mains, copper services, other services, main gate valves, meter boxes, meters in the field, meters in the shop, and hydrants.

TABLE 2

Distribution Division Summary by Districts

Breakdown	Actual Expenditure	Budget	Variation
Distribution Division office			
General supervision	$ 1,400	$ 1,250	−$150
Distribution engineering	1,620	1,500	−120
General clerical expenses	1,235	1,120	−115
Other expenses	216	250	+34
Subtotal	4,471	4,120	−351
District totals			
First District	35,579	26,300	−9,279
Second District	27,963	24,490	−3,473
Third District	21,542	20,450	−1,092
Subtotal	85,084	71,240	−13,844
Total	$89,555	$75,360	−$14,195

TABLE 3

Distribution Division Summary by Function

Breakdown	Actual Expenditure	Budget	Variation
Overhead			
Supervision	$ 3,627	$ 3,490	−$137
Distribution engineering	4,721	4,150	−571
General clerical expenses	4,715	4,200	−515
Other functions	676	500	−176
Subtotal	13,739	12,340	−1,399
Operation			
Inspecting distribution system	4,181	3,820	−361
Investigating water leaks	1,322	1,210	−112
Operating distribution system	2,501	3,200	+699
Operating distribution reservoirs	3,472	3,250	−222
Groundskeeping on rights of way	6,932	3,570	−3,362
Hydraulic tests and flow measurements	1,433	1,575	+142
Removing and resetting meters	4,632	3,810	−822
Services on customers' premises	2,371	2,000	−371
Other functions	1,642	1,375	−267
Subtotal	28,486	23,810	−4,676
Maintenance			
Maintaining exposed mains	2,374	1,810	−564
Transferring services to new mains	4,316	2,850	−1,466
Repairing equipment*	36,687	31,350	−5,337
Other functions	3,953	3,200	−753
Subtotal	47,330	39,210	−8,120
Total	$89,555	$75,360	−$14,195

* See footnote for Table 1.

ity of different size and organization. (Responsibility accounting has been described in greater detail in an article by McDaniel, of the same firm as the author (*2*). Some of the tabular material that was used in the McDaniel article is repeated here.)

District Reports

The first level of reporting is the district (Fig. 1). Table 1 shows the responsibility statement submitted to the supervisor of the First District. A similar type of statement would be submitted to the supervisors of the Second and Third districts. This statement shows by natural divisions of work all costs for which the supervisor of the district is responsible. These work operations are designed to fit the particular requirements for each department or organizational unit. The supervisor participates in determining what these functions are to be. They are described in his own terms so that the statement can be easily understood by operating personnel. Table 1 shows that, in the First District, overhead, operation, and maintenance totaled $35,579 in the period covered.

Division Reports

Table 2 shows the report prepared for the superintendent of the Distribution Division, who supervises the three districts. The cost total of $35,579 is carried over from the responsibility statement from the First District. Costs for the other districts are also shown, plus the costs of the Distribution Division office. The total expenditure is $89,555.

Another (Table 3) report received by the Distribution Division superintendent itemizes the $89,555 expenditure by functions without regard to the districts. This report tells the superintendent the total costs of each operation for which he is responsible. The total costs for overhead ($13,739), operation ($28,486), and maintenance ($47,330) will be carried forward to the report for the next higher level of responsibility (see Fig. 1).

Department Reports

The Distribution Division is one of the divisions reporting to the head of the Operating Department (Fig. 1). Table 4 illustrates the report prepared

TABLE 4

Operating Department Summary

Breakdown	Operation			Maintenance			Overhead		
	Actual Expenditure	Budget	Variation	Actual Expenditure	Budget	Variation	Actual Expenditure	Budget	Variation
Operating Department supervisor	$ 4,922	$ 4,230	−$692	$ 3,792	$ 3,630	−$162	$ 5,612	$ 5,500	−$112
Water Supply Division	4,168	4,200	+32	2,043	1,750	−293	1,826	2,000	+174
Transmission Division	11,322	9,090	−2,232	14,716	10,220	−4,496	4,312	3,620	−692
Distribution Division	28,486	23,810	−4,676	47,330	39,210	−8,120	13,739	12,340	−1,399
Pumping Division	15,714	13,900	−1,814	10,042	8,860	−1,182	3,012	2,660	−352
Purification Division	21,026	18,100	−2,926	6,511	5,200	−1,311	2,992	2,400	−592
Subtotal	85,638	73,330	−12,308	84,434	68,870	−15,564	$31,493	$28,520	−$2,973
Overhead allocated to:									
Operation and maintenance	5,504	4,526	−978	6,181	4,921	−1,260	($11,685)	($10,838)	(−$847)
Construction and other							($19,808)	($17,682)	(−$2,126)
Total	$91,142	$77,856	−$13,286	$90,615	$73,791	−$16,824			

for the department head. The totals for overhead, operation, and maintenance have been carried over from the Distribution Division summary (Table 3). Totals from reports prepared for the other divisions have been carried forward in the same manner and their sum constitutes the total costs to the department for operations, maintenance, and overhead.

The total costs for each division are supported by statements prepared on a strict responsibility basis similar to the examples shown in Tables 1–4. In the detailed responsibility reports over-

total expenses for the Operating Department (Table 4), similar detailed and summarized reports from the other three major departments (see Fig. 1), and a statement of "general" expense. Table 5 is an example of how these reports are summarized. The totals of $235,177 for operations and $90,615 for maintenance are carried over and included in total operation and maintenance expense in the final income and expense statement (Table 6).

The information in this final statement is an essential part of the report that goes to shareholders, commission-

TABLE 5

Departmental Expense Summary

Breakdown	Actual Expenditure	Budget	Variation
Operations			
Finance Department	$ 44,828	$ 42,750	−$2,078
Personnel Department	14,289	12,360	−1,929
Operating Department	91,142	77,856	−13,286
Commercial Department	60,069	56,250	−3,819
General	24,849	25,200	+351
Subtotal	235,177	214,416	−20,761
Maintenance	90,615	73,791	−16,824
Total	$325,792	$288,207	−$37,585

heads are controlled as totals without regard to whether the accountants will ultimately assign them to expense or construction.

At this accounting level the overhead is allocated to operations, maintenance, and construction and other, as shown by the parenthesized amounts in Table 4. The total amounts of $91,142 for operations and $90,615 for maintenance are carried forward to the next-higher level report.

Final Reports

The manager of the water utility receives the report which shows the

ers, a city council, the citizens of the community, or any other group or groups to which a utility must submit an accounting. It is fully supported by statements adapted to management's needs and desires for control of expenses on a responsibility basis. If reports by commission-prescribed accounts are desired, the conversion can easily be made by simple accounting techniques.

Review

A review of the stages in responsibility accounting may be of value:

1. The supervisor of each district receives a report of the costs for which he is responsible and which are under his control (Table 1).

2. The total from this report is carried forward to the divisional level and there combined with the reports from the other districts (Table 2). A report to the division superintendent subdividing the total costs for all districts under overhead, operation, and maintenance is also prepared (Table 3).

3. These reports are then forwarded to the department head. At this level they are combined with the reports of the other divisions and the overhead totals are allocated between construction and other and operation and maintenance (Table 4).

4. The totals for operation and maintenance are combined in a summary of the expenses of all the departments for the manager of the utility (Table 5). These final totals are used in a statement of the income and expense of the utility (Table 6).

Advantages of Responsibility Accounting

Some of the more important advantages of responsibility accounting are:

1. Cost reports are simple, concise, and easy to understand. A report which can be understood by operating personnel is much more likely to be used by them than one which can be interpreted only by an accountant.

2. Responsibility for costs is clearly indicated in all reports because the reports are adapted to fit the individual utility at each level of authority.

3. Responsibility accounting permits effective budgeting and budgetary control by providing for the identification of individuals responsible for variations from the budget. This can easily be seen by the way the reports (Tables 1–6) relate to each other, with

TABLE 6

Statement of Income and Expense

Item	Actual Expenditure or Collection	Budget	Variation
Operating revenue			
Water sales and services	$681,618	$665,300	−$16,318
Other	18,752	20,000	+1,248
Total operating revenue	$700,370	$685,300	−$15,070
Operating expenses			
Operations	$235,177	$214,416	−$20,761
Maintenance	90,615	73,791	−16,824
Depreciation	175,833	175,833	0
Taxes—federal income	8,600	11,800	+3,200
Taxes—all other	27,970	28,000	+30
Other operating expenses	32,625	31,360	−1,265
Total operating expenses	$570,820	$535,200	−$35,620
Net operating income	$129,550	$150,100	+$20,550
Other income	7,162	7,000	−162
Gross income	$136,712	$157,100	+$20,388
Income deductions	73,634	74,584	+950
Net income	$ 63,078	$ 82,516	+$19,438

variations from the budget shown in detail by each natural division of work. Variations can be traced to specific invoices or labor charges if necessary.

4. The logical way to prepare a budget in any organization is first to plan the work to be done and then estimate the cost of doing it. The common-sense method of accomplishing this would be to estimate expenditures by the natural divisions of work. If, however, expenditures are recorded only by the "uniform" classification of accounts it is more difficult efficiently to plan a budget or to determine the causes of budget variation from estimated costs or variation from costs in previous years than if responsibility accounting is used. As an illustration of this: in the uniform classification account, "operation of distribution lines" would be a single budgetary item; in responsibility accounting this item is subdivided according to natural division of work and appears in the representative water utility reports described in this article as the first six breakdowns under "Operation" in Table 3.

5. With the growth of a water utility's business its cash position and cash requirements assume greater significance. The adequacy of forecasting cash needs is determined by the adequacy of the underlying budget or plans on which the forecast is based. Responsibility accounting provides a basis for establishing and managing realistic plans or budgets for all expenditures.

6. The same general pattern of building up cost reports on a responsibility basis can be readily applied to construction expenditures, which should be controlled on the same basis as other items in a utility budget. Such reports for construction should not only provide a comparison between amounts expended but also give the amount of purchase commitments and the amounts unexpended and not committed.

Conclusion

Modernized accounting is an important tool of management, regardless of the size of the organization or whether the business is publicly or privately owned. It is the source of basic information helpful in solving virtually all types of management problem including: rates; financing, planning, and control of operations; maintenance; and construction.

"Modernized accounting" is a broad term and what is modern to one utility may be old to another. This article has covered, however, the basic factors of a modernized accounting system.

References

1. *Iowa-Illinois Gas and Electric Co.* v. *City of Fort Dodge, Iowa, et al.* Supreme Court of Iowa (1957).
2. McDaniel, T. M., Jr. Expenditure Control Through Responsibility Accounting. *Jour. AWWA,* **45**:1298 (Dec. 1953).

Water Rights Law in Iowa

M. K. Tenny

A paper presented on Oct. 16, 1958, at the Iowa Section Meeting, Des Moines, Iowa, by M. K. Tenny, Secy. & Gen. Mgr., Water Works, Des Moines, Iowa, and Chairman, Committee on Water Rights Law, Iowa Section.

CHAPTER 455A of the Code of Iowa, as amended by the Iowa legislature in 1957, provided for an office of water commissioner, to be chosen by the state's Natural Resources Council. The commissioner's duty is to process all applications for water appropriation permits. In September 1957 Richard Bullard, formerly acting director of the Natural Resources Council, was appointed commissioner by the council, which also employed deputies to assist him.

Present Policy

The job of water commissioner in Iowa is not an easy one. There is not now available all the water that everyone wants, and as the demand increases the situation will become more difficult. Fortunately, 1958 was a wet year; July, which is usually the critical month, was the wettest on record in the central part of Iowa.

In most cases it seems to have been the policy of the commissioner to approve all requests for water. Applicants have been allowed all of the water they ask for that the commissioner or his deputies determine can be beneficially used. Up to the present time (October 1958) hearings have only been held by the commissioner's office on a very few applications where opposition has been offered by parties claiming to be aggrieved.

A release from the commissioner's office, dated Sep. 30, 1958, records 1,103 applications for water: 475 for irrigation, 83 for recreation, 186 for industrial use, 37 for municipal use, and 322 short-term applications for use of water in highway construction. In an agricultural state such as Iowa it is not surprising that irrigators comprise the largest group of applicants. Irrigators are also the most difficult group to satisfy because irrigation is a depleting water use and it is likely to be most necessary during the time of minimum stream flow.

There does not seem to be any record yet of an application to the water commissioner being flatly denied. The policy seems, rather, to have been to grant a permit for the amount of water that the commissioner believes can be used beneficially. In cases where opposition to the permit has arisen, use at times of low stream flow has been limited in order to attempt to comply with the law which provides for preserving the established average minimum flow.

In the case of the first three irrigation permits issued, all involving the Maple River, there seems to have been doubt on the part of the opposition that a satisfactory minimum flow could be

preserved if the amount of water applied for was taken from the river. These permits were appealed to the Natural Resources Council, which sustained the water commissioner. It now appears that conservation officials of the state and others will bring a lawsuit to settle legal questions involving use of irrigation water. Needless to say, policing irrigators and keeping records of their water use will be very difficult tasks.

Disputed Applications

Perhaps of more interest to operators of public water utilities are the findings in the case of the application of West Des Moines, Iowa (a municipality separate from Des Moines), to take water from Ranney-type wells * on the bank of the Raccoon River. A permit (No. 1A, later superseded by No. 1B) to do this was issued by the commissioner. The Des Moines Water Works opposed this application, partly on the ground, stated by Chapter 455A of the Iowa Code, that: "Persons who have made diversion or withdrawal of water for beneficial use prior to the effective date of this act will be accorded priority." The Des Moines Water Works had taken its supply from the Raccoon River for more than 75 years. West Des Moines was proposing to change its source from shallow wells approximately 1 mi from the Raccoon River to the river itself, in effect. The engineers for the manufacturers of the Ranney wells, who had contracted to do the work for West Des Moines, apparently concurred in the conclusion that it was a change from a ground water supply to a river water supply. In respect to a well in the area the Ranney report stated: "The effective distance to the line of infiltration, as measured from the pumping well, is computed to be about 700 ft."

The original decision of the commissioner would have allowed West Des Moines to use the river as its major source of supply and permitted it to withdraw approximately twice as much water as it had ever previously used. This use, however, had a time limit of 3 years, pending further study of the situation. West Des Moines appealed to the Iowa Natural Resources Council and the time limit was extended by the council to 10 years (the maximum). A clause relating to future storage facilities was added by the council.

The Des Moines Water Works then appealed to a US District Court to require West Des Moines to furnish water storage if it was to withdraw water from the Raccoon River between the Des Moines storage reservoir near Commerce, Iowa, and the Des Moines river intakes. A consent decree was finally worked out which provided for a payment by West Des Moines of its proportionate share for the use of the reservoir.

Another feature of interest in the West Des Moines case was a subsequent decision by the commissioner that West Des Moines could transfer some of the water capacity allotted to it to another source. West Des Moines was granted the right to purchase water taken from the well of the Penn-Dixie cement plant, which also used the Raccoon River as its source, and the Penn-Dixie plant was automatically allowed to increase the capacity of its well to withdraw water. This may establish a policy in Iowa

* Manufactured by Ranney Method Water Supplies, Inc., Columbus, Ohio.

that once rights to a quantity of water are obtained these rights may be transferred. This is the usual policy in some of the western states.

The author wishes to repeat that the policy of the Iowa water commissioner seems to be to approve all applications for what he and his deputies decide are beneficial uses of water. If an application is opposed the burden of proof is placed by the commissioner on the opposition. The action taken on the application of Community Builders, Inc., to withdraw water from a well on the bank of the Raccoon River, a few miles above Des Moines, illustrates this.

The decision of a deputy commissioner, who was the hearing officer for this application, states that: "The hearing officer believes that the burden of proving the basic assumption and the resultant damage claimed by the opponent is a burden of the opponent. . . . If the Board of Water Works Trustees of the city of Des Moines is acting in good faith in urging its objections to this request, it . . . should be willing to join with applicant corporation in financing and conducting the installation and operation of observation wells." This has been appealed to the State National Resources Council.

It can readily be seen that the cost of protecting a water supply may become tremendously expensive if it is the burden of the opposition to appeal every application that may come before the commissioner, no matter how speculative in nature it may be. How prohibitive this cost may become is illustrated by an action of the state executive council in October 1958. The council discharged a private attorney retained by the State Conservation Commission to challenge permits issued by the water commissioner's office by contending that withdrawal of water from streams would be harmful to fish and wildlife and would interfere with recreational activity. This action was taken because the council had learned that more than $4,000 had already been paid for private attorney's services for this same purpose.

At the time of the action by the water commissioner's office on the application of Community Builders, Inc., this corporation was in serious financial condition. Little, if any, building had been started in the area to be furnished with water under the application and progress on construction at the corporation's former development site had come to a stop. For them to be granted the right to withdraw 120 mil gal of water per year to supply 6,000 at present nonexistent consumers and to start a new development and not be required to maintain water storage (as present users along the Raccoon River must do) could be construed as giving this corporation a merchantable commodity in preference to the prior-right users.

Conclusion

Under the riparian doctrine, which was the law in Iowa previous to the enactment of Chapter 455A, a person owning riparian property was entitled to the use of the water flowing by in its natural current or channel, undiminished in quantity and unimpaired in quality. Modern courts, however, have adopted the principle of "reasonable use." This makes it the duty of the courts to determine who is entitled to how much water.

Chapter 455A, as amended in 1957, states: "The water commissioner shall

serve in a quasi-judicial capacity as the trier of fact questions in the processing of all applications for appropriation permits." The source of the facts made available to the commissioner, therefore, has become of basic importance. Whether the Natural Resources Council or some other public agency is charged with the responsibility of research in this regard or whether it will be left to the applicant for water and whoever might oppose him will have a great deal to do with the future of water control in Iowa.

The Iowa Geological Survey in conjunction with USGS, compiles records of stream flow in Iowa, and has done so for years. Apparently, however, these records are not always sufficient. Even if they were, however, under the provisions of Chapter 455A the records may not always be used by the water commissioner's office to the best advantage of all parties concerned.

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Departmental Autonomy for Municipally Owned Utilities

John R. Fee

A paper presented on Oct. 30, 1958, at the California Section Meeting, Los Angeles, Calif., by John R. Fee, Asst. Chief Engr., James M. Montgomery, Cons. Engr., Pasadena, Calif.

HOW closely should a city council monitor the management and operation of the city's water department? This article will present one person's general analysis of this perpetual question—a question that invariably creates debate and disagreement. The term "city council" is intended as the general name for any governing body of a city, even though that body may be called a commission, a board of directors, or some other title; and the remarks made here could also be extended to apply to other municipally owned utilities.

The dictionary defines a monopoly as exclusive control of the supply of any commodity or service in a given market. A water utility usually has such control because it is uneconomical for several water purveyors to attempt to serve the same customers. It would be impractical, for example, for each of several companies to install a separate main in the same city street. Therefore, one organization is normally franchised to serve water within each community and enjoys a local monopoly on the sale of water. If the organization is privately owned, its operation probably is controlled by the state through a public utilities commission. If the water utility is municipally owned, the management and operation of the utility, in most states, remains with the municipality. It behooves each city with this authority to adopt a water system management and operation program which will safeguard against the misuse of such a monopolistic control.

Self-Sufficiency

An important principle, which will be the basis for most of the arguments presented in this article, is that a municipal water system should be financially self-supporting, and only self-supporting. When operated as a separate enterprise, a water system is usually capable of producing sufficient revenue through its operations to offset all expenses and to finance normal growth and replacements. In this respect, a water department differs from most other city agencies.

The purpose of a municipal water system is to provide the community with an adequate supply of water at reasonable cost. The author believes that those who benefit from the system should finance it, and each should share his own proportional cost of the system. The methods of distributing the costs are the basis of an equitable water rate structure.

Although, in principle, a water utility should be entirely self-sufficient,

there is an exception. If the economic development of a community is dependent upon the provision of an extensive water supply system, such as necessitates the construction of a large dam or an expensive aqueduct, then the cost of such facilities can justifiably be charged to the taxpayers. Because these water facilities benefit the community as a whole, it is fitting that the owners (taxpayers) should underwrite and finance these costs.

Local system improvements, such as the drilling of a well or the extension of a water main, differ from the long-range projects discussed above. The primary purpose of these local improvements is to deliver water to the customer; therefore the costs of such improvements should be borne by the water user. If such local improvements increase the value of a vacant lot or other property that presently has no water demand, then the owner of the property should bear his fair share of the local improvement costs. This share may be collected by assessment of a standby charge.

Because a water utility is capable of producing revenues and because these revenues should be used only to serve the specific end for which the utility was created, special consideration must be given to the type of management structure established for administering a municipal water department.

The principal differences between management structures of municipally owned water utilities lie in the degree of policy-making power retained in the city council. On the one hand, the council may be the chief legislative body of the water department and directly act on all policy matters; on the other, the authority for policy formation may be vested in an independent board of commissioners, and the council may retain only a few veto and appointive powers. Each extreme has some advantages over the other.

Direct Council Control

The word "coordination" best explains the advantages of direct city council control. Because a municipal government is composed of several departments, it is essential that the operation of all departments be so regulated that there is mutual cooperation between them. The work of a water department usually overlaps certain phases of the work of other departments. The following examples illustrate this point:

1. The paving of city streets must be coordinated with the replacement or extension of water mains.

2. The location and number of fire hydrants should be of paramount importance to the fire department, and it is equally important that that department be promptly informed of any emergency or major changes affecting water service for fire protection. It may also be desirable for a representative of the water department to be available at fires for operating valves and other water system facilities.

3. The locations of water mains in city streets must be coordinated with the planned locations of sewers and storm drains.

4. Decisions of the planning department must be consistent with the financial ability and the construction timetable of the water department.

5. The park department usually has a high water demand. If this demand can be restricted to off-peak periods, the efficiency of water distribution can be materially improved.

6. The police department often is needed to report emergencies, control traffic, and protect facilities.

7. Services of the health department can be utilized on both a scheduled and unscheduled basis.

8. Economically, it may be desirable for the water department to bill or collect for other city services, such as garbage collection or sewer charges.

9. The unit cost of materials, supplies, and equipment may be reduced if the water department obtains them through the city purchasing department.

10. The water department always needs legal, technical, and financial advice. These services may be economically available through the city's attorney, engineer, and financial director.

11. The water department and building department must cooperate in order that realistic building schedules and codes may be developed.

The activities of the several departments can be intelligently integrated by an agency that has policy authority for all departments. The agency in this instance would be the city council. If conflicts of interest arise between departments, the city council, being familiar with the role each department plays in the municipal government, could rule on the situation in the best interests of the city as a whole.

Control by Independent Board

There are many advantages if the management and operation of a water department are under the control of an independent board of commissioners—particularly if the board is appointed, rather than elected. These advantages are principally those of freedom from political pressures and autonomy of management control. Some of them are summarized below.

1. An appointed board should have freedom to act in the best interests of the utility without concern about the political implications of its actions.

2. The commissioners should be high-caliber men selected for their knowledge and experience in the business, engineering, and financial worlds. Such men often are willing to contribtue their talents as a civic responsibility. A board so selected could give trained leadership to the water department. On this basis, the utility would be managed and operated as an independent business entity.

3. A board of commissioners with staggered, long-term appointments and possible reappointments would permit long-range planning to be developed and followed through. Continuity of management is necessary and desirable in a good water supply system. This feature is recognized by the NBFU. Short tenure of office for administrative executives would result in charging NBFU deficiency points against the water system.

4. The board of commissioners, acting as a liaison, would reduce the amount of politics in which the water department manager would have to be engaged and thus permit him to turn his energies towards developing an efficient organization.

5. Probably the outstanding advantage of controlling the management of a water department with an independent board is the reduction in likelihood of indiscriminate transfer of water funds to other city departments. Such subsidies are outlawed in many cities by charter; but an independent board, with full control of the water department's budget, could permit the water department to accumulate a justifiably large construction fund without fear of its being siphoned off for other municipal uses. The practice of using water department funds for anything other than direct water department obligations has the same effect as im-

posing a general municipal tax on water sales. No matter what form of utility management is adopted, such indiscriminate transfers should be prohibited by legislation.

6. An independent board is more likely to be free to adjust water rates when, in the best interest of the utility, it is essential that the rates be changed. Such an action on the board's part can be done without fear of political consequences, and the rate can be established on its technical merits, rather than manipulated for political appeasement.

7. Sometimes it is easier to initiate successfully a needed bond issue if it is presented by an independent committee of citizens, rather than by a political group.

8. Modernization of the plant may be desirable and economical. Such a step is easier to promote if the management is not influenced by politics.

Types of Management

There are many forms of management for municipally owned water utilities—none of the forms, however, is without shortcomings. The types of management also may fall somewhere between the two extremes discussed above. For example, the management of the water department may be under the control of a committee of the council or under the subcontrol of the mayor, city manager, or a councilman (commissioner). If the utility is controlled by an independent board of commissioners, an appointed board is preferable to an elected one, because the former has more freedom from political influence.

Direct, councilman control is by far the most common type; there is, however, a distinct trend, particularly in the larger cities, toward adoption of the independent-board type of control. Also, the increasing popularity of the council-manager form of municipal government has shifted the burden of responsibility for departmental coordination from the council to a city manager who is an experienced man trained in city administrative work. This change avoids many of the disadvantages of the independent-board type of control and has paved the way for the administrative change of placing the water department under the control of an independent board.

Control of a municipally owned water utility by an independent board is not a new idea on the West Coast. Los Angeles has successfully employed this method since 1903, and has found it efficient, effective, and practical. Normally, the larger the water utility the less it need depend upon other city departments. For this reason, the independent-board type of control seems to be better suited to larger cities; there is no reason, however, why the method should not be workable in a progressive city of any size.

Organization of Independent Board

Placing the water department under the control of an independent board of commissioners does not mean that the citizens and the city council must relinquish all control of the utility—far from it. The customary arrangement is to distribute the authority and limitations of control. The general public, through its voting privileges, retains its right to alter the charter or other document under which the independent board was authorized, approve major bond issues, and select the city councilmen.

The mayor, with the approval of the city council, can supervise the actions of the independent board by exercising many water department controls,

among which are the power to appoint board members, approve various financial measures and rate structures, require checks of records and operational procedures, approve the sale of real property, and assume direct control in emergencies.

The independent board of commissioners usually receives complete jurisdiction over the management and operation of the water department and usually is specifically charged with the appointment and removal of the manager of the water system, long-term planning and development, preparation of the annual budget, development of an accounting and record system, fixing of rates for water sales and services, determination of the size of staff and number of employees, defining the positions and salaries of all executives and employees, approving contracts and purchase of materials and so on.

Some argue that an independent board should not be permitted to fix the salaries of its executives and employees—that this should be a responsibility of the city personnel department who would coordinate the job descriptions and salaries of the water department personnel with those of other city employees. On the other hand, it must be remembered that the basic principle of operation of the water department is that it should be a separate business entity. As the amount spent for wages and salaries normally represents over half of a water department's operating expenses, and as the heart of an efficient water utility organization is the attraction and retention of qualified and trained executives and employees, it is essential that the board have control over this phase of management.

It may sometimes be economical and desirable to have certain functions that normally are required by the water department handled by other departments of the city. No uniform rule can be established, however, except that each situation must be carefully studied in terms of its effect on the water department and the city. In general, it seems that most water departments, particularly the larger ones, can function most efficiently and economically by handling all of their functions within the department. The most serious drawback of performing water department functions outside the department is the possible resulting lack of liaison. It is essential that the right hand know what the left hand is doing—particularly if one hand is performing operational functions and the other hand is handling the financial arrangements for those functions.

Summary

The author realizes that local conditions may dictate the control structure best suited for the management and operation of a particular municipally owned water department. The evaluation of the method of control must, however, be approached with an unbiased attitude and with a goal of developing a water department that, over a long period, will adequately serve the community and return the most good to its citizens. In making such an evaluation, whether it be for the establishment of a new water department or an investigation for a possible revision of the method of control of an existing water department, it is important to remember that a municipally owned utility should be financially self-supporting, and only self-supporting. This means the water department must be treated as an independent business entity. If it is to act as such, it must

accept full financial responsibility for all its costs.

The cost of all services received from other city departments should be secured on a contracted or interdepartmental charge basis. In lieu of taxes, the water department should contribute to the city's general fund. For budgetary convenience it may be desirable to contribute a certain percentage of gross revenue, but this amount should be roughly equivalent to that obtained by applying the pertinent local tax rates to the assessed value of the department's actual property. If the city is inconvenienced by lending its credit to the water department for the support of a general-obligation bond issue, then the city's general fund would be justified in collecting a fee from the water department. If the water utility uses buildings or grounds originally financed by other city agencies, the water department should pay a fair rental for those services.

It is equally important that the water utility charge for all the services it renders to others, including other city departments. Most water departments furnish water for fire protection purposes in addition to the normal consumer demands. The enlargement of the physical plant and properties of the water department necessitated by this commitment usually amounts to a considerable outlay of capital. The cost of furnishing fire hydrants, larger transmission mains, extra booster pumping capacities, and additional storage capacity is considerable and should be refunded to the water department from the appropriate city fire protection funds. For bookkeeping convenience, this return may be on a hydrant rental basis, but the charge should be realistically adequate.

Water furnished to irrigate parks, flush sewers, and serve the city hall, should be sold on a contracted or unit-cost basis at the same price that is charged to other water customers.

The water department should also be reimbursed for the cost of services to other city agencies, such as mailings, shop repair work, and gathering special research data.

Conclusion

Good management and operation of a municipally owned water utility must be backed by informed leadership that is working energetically to promote, develop, and utilize the department to the economic limit. In attempting to create this type of leadership, the merits of an independent board of commissioners should not be overlooked.

Equally important in the development of an efficient organization is the need for harmony and mutual confidence among the various city officials and departments. The advantages of a council–manager form of municipal government, working either with or without an independent board of water commissioners, potentially can help to promote the needed spirit of cooperation.

Trends in Water Utility Development

Wendell R. LaDue

A paper presented on Sep. 18, 1958, at the Ohio Section Meeting, Cleveland, Ohio, by Wendell R. LaDue, Chief Engr., Bureau of Water Supply, Dept. of Pub. Service, Akron, Ohio.

THE word "facility" is usually thought of as implying an aid or a convenience—a readiness to serve. In a discussion of the changing philosophy regarding water facilities it is essential that the philosophy of water *supply* be distinguished and separated from the facility of water *distribution*. In a water supply system, the principles regarding development of source and subsequent water use form a background or prelude to the consideration of the philosophy of water distribution and sale.

The fundamental principles of water use and the attendant development of a potable source have undergone many changes. Originally, in the simplest sense, a water supply was a well or spring supply pipe to a house and either delivered by gravity or pumped by a windmill. A water supply for industry consisted of a low dam with a water wheel furnishing power for an individual mill or shop. This formed the basis of the "mill-by-the-stream" philosophy of riparian rights on a stream where a series of mill owners operated when each was assured that the water flowing through his property would not be changed, either in quality or quantity. It is unfortunate that, in the eastern section of the United States, a similar code for underground water supplies does not exist.

Increased demand for and uses of water resulted in the first change in this "mill-by-the-stream" philosophy. The need for cooperative endeavor, the pooling of interests, and the construction of larger units for the users of the water developed and emerged. This led to the concept that corporate utilities, with either private or public ownership, own water rights beyond the limits of their streamside property.

The principle of conserving, developing, and diverting water from a stream by the acquisition of the water rights of others followed, and the concept of a water supply system owned and operated independently of the riparian owners was born. Although the individual owners could not control the availability and use of their rights beyond their property, the utility could do so. Water is the lifeblood of any community, and each utility is much concerned with the control and use of the water rights for the community served and is often reluctant to share its good fortune, having procured an ample supply of potable water for itself.

Trends in Water Rights

A modern trend in water rights is exemplified in a Mississippi law,

passed in 1956. Mississippi became the first of the 31 humid-area states to adopt the principle of surface water appropriation. In its declaration of policy, the act states:

> The general welfare of the people of the state of Mississippi requires that the water resources of the state be put to beneficial use to the fullest extent to which they are capable . . . and that the public and private funds for the promotion and expansion of the beneficial use of water resources shall be invested to the end that the best interest and welfare of the people is served.
>
> Water occurring in any watercourse, lake, or other natural water body of the state, is hereby declared to be public water and public wealth of the state and subject to appropriation in accordance with the provisions of this act.

This legislation does not take away the rights of any person. On the contrary, it recognizes some definite rights for persons owning property along a stream, essentially as follows:

1. Water below the average minimum flow cannot be appropriated.
2. Domestic use is broadly defined. A riparian owner's right to use water for domestic use is maintained.
3. A person may construct a dam if it does not interfere with rights or appropriations below the dam.
4. All persons, including municipalities, using water prior to Apr. 1, 1958, can file claims to have their water rights established and sustained and may continue using water to the maximum extent used in any one year. A riparian owner not using water before April 1, 1958, can apply for an appropriation of water.

Additional use of water can be approved on the following basis:

1. Application must be filed with the board of water commissioners.
2. Permit will be granted if it can normally be expected that there will be sufficient water in addition to the minimum flow, plus prior appropriations.
3. When the flow of the surface water supplies is insufficient for additional appropriation the applicant may impound flood waters.

The law governs municipal users of water as follows:

1. Rights are based on maximum amount used in any one year prior to Apr. 1, 1958.
2. After a permit is granted the water must be put in use within a reasonable time. This can be 20 years for municipal users.

Water rights are extremely important because they provide for an orderly development of surface waters. The four major types of water use—agricultural, industrial, municipal, and recreational—*are all recognized on an equal basis.* The priorities regulation can be summarized as: first in time, first in rights. There are no restrictions on the amount of water that may be used for domestic use or the time in which it may be used. Other states now have similar basic laws. The Mississippi example was given to illustrate one instance of present thinking.

The water needs of areas outside of the cities have increased greatly in recent years. Some of these needs have been met by the central city. This applies not only to residential use and fire protection, but also to the ever increasing demand of commercial consumers for plant use and fire protection. The growing concept of a metropolitan area about a central city makes it logical and economically sound for these areas outside of the city to be served by the coordinated expansion of the central-city water utility. The interdependence of the industrial and

commercial life of the city and the more personalized residential life of the surrounding suburbia, occupied principally by central-city workers, makes the old idea of a municipally owned and operated water utility serving only the central city impracticable and, in many cases, insupportable.

The original concept of the "mill-by-the-stream," when applied to cities, is one of isolation and is no longer acceptable in many locations. This concept implied the conservation—or hoarding—of the fixed water resources of the individual water utility for itself. Long-range planning for water utility expansion into the territory *between* any two or more present water utilities calls for coordinated study and a philosophy of understanding by the heads of the utilities involving the development of good will and recognition among the residents of the areas—those who need the service.

Watershed Control

Cities, large and small, are generally part of a watershed and their various interests and influences extend beyond their corporate limits. Therefore cities should be given considerably greater consideration and weight in a watershed study than is to be indicated by the ratio of the cities' areas to the total area of the watershed. To a great extent the interests of cities, and their adjacent "suburbias," govern the type of a reasonably balanced development of a given watershed. Often it is found that cities, *outside* of a watershed area, lend their influence in the development of a particular watershed. This is especially true of a medium-size watershed which may be one of several within ordinary travel distance of a metropolitan area.

A city's overall primary interest in watershed development involves intercity highway location. This in turn reflects the location of secondary roads with related residential, recreational, and industrial land use. This thinking becomes, essentially, watershed planning and zoning. It should be considered such. Water supply and sewage disposal are essentially city interests in the watershed; hence, noncity residents should be vitally interested. It is obvious that satisfactory city domestic water supply and sewage disposal are of prime importance to the health and recreational activities of all in the watershed area.

The product of the watershed is as important to the welfare of the city and "suburbia" residents as is the product of the "milkshed." It is well known that health boards and the dairy industry exercise close control over the dairy products furnished the consumers within the jurisdiction of the health board and the dairy organization. To insure that satisfactory dairy products are delivered, the requirements of the board and the dairy industry are paramount in the use and operation of the individual dairyman's property.

The water utility likewise is entitled to its *paramount* control over all watershed activities which in any way affect the health and well being of the water consumers of all contributory areas. This fact must be brought to the attention of all interested in watershed development problems, whether the problem be one of land use or water supply, to insure a proper sense of balance of needs between city, suburban, and rural activities. The moot questions are economic and involve primary planning of the supply and distribution facilities and the allocation of the cost

of expansion of urban facilities to serve outlying areas. The head of the utility must of necessity be governed by the primary program of the city administration in the handling of corporate development and of expansion of municipal activities into the fringe area adjoining the city. Due regard must be given to the normal and natural economic problem of correlary functions, such as police and fire protection, utility expansion, and necessary coordination of main highway construction.

There are three basic methods by which a water utility's service area may be extended beyond city limits. They are: [1] planned city annexation, [2] independent utility expansion, and [3] special authority.

Planned Annexation

Often state funds are distributed to cities and other political subdivisions on the basis of population. City administrations are anxious to obtain an increase in these funds, and they therefore often annex well populated areas with little regard for the city's ability to supply the necessary city functions, including water supply, to these areas. Likewise, an administration may be pressured by real estate developers to annex small areas. This program adds to the real estate sales "pitch" and is also financially advantageous to the developer with regard to street and utility improvements.

In states in which annexation is the basic format for utility expansion and is well understood and accepted, it is vital that adequate, fairly long-term expansion of utilities be made mandatory. Realistic legal planning and financial policies for both the annexor and the annexee are essential for proper functioning of this procedure. In such planning, legal and financing programs must be supported by adequate state laws.

Independent Utility Expansion

In various forms, a policy of selling water and extending service beyond city limits has been the general policy in Ohio. There is an ethical and, in some states, a legal responsibility to supply water outside of the corporate limits. Once such a policy has been established, the utility cannot differentiate, depriving certain sections of water while supplying other sections.

A few of the important features of procedure are that:

1. Extensions may be made at utility expense and consumers billed separately, as within the city (Individuals may reimburse the utility for a portion or all of the expense.)
2. Construction of mains and necessary pumps and storage may be made by cities, villages, or county-sponsored sewer districts (Maintenance, operation, and billing may be assumed by the utility.)
3. Construction of all water facilities may be made by a city or village desiring the service (Water is sold by master meter to the city or village, which establishes its own water utility for operation and management of the system.).

Special Authority

It is often desirable to create a special authority or district to develop, maintain, and operate an overall water system to deliver water to several individual political subdivisions for distribution and sale by them. This is dependent upon the primary overall phi-

losophy regarding the corporate development and expansion of the metropolitan area.

Ohio voters in November, 1958, voted on a constitutional amendment to permit the formation of a metropolitan federation based upon a city with a population of at least 50,000. It is believed that the 1960 census may show sixteen counties with cities having a population of at least 50,000 and six counties in which the county charter amendment, adopted in 1957, is applicable.

A preliminary review of the proposed amendment indicates that the amendment retains to the various existing political subdivisions all of their rights and privileges, except those specifically assigned to the federation, which could include the development of a coordinated water supply system.

Financing of Extensions

Financing of any extension or development outside of the central city, whether by the central city of the metropolitan area or by a special authority, involves the question of an equitable allocation of charges by the city and to the various areas concerned. The utility must protect the interests of the city consumers who have paid in the past for the construction of a system adequate for their own needs, but at the same time must recognize the need of the city for adequate facilities in the fringe areas to support and protect the industrial and commercial well-being of the central city.

Generally, the financing involves charges for water based on a surcharge over city rates. When relatively long-term agreements are made with other political subdivisions it is desirable that provision be made for automatic adjustment in keeping with the adjustments of charges within the city.

Surcharge on bills to outside consumers should, in equity to city consumers, provide allowance for the following:

1. Cost of additional plant construction necessary for the expected load. This includes primary treatment, pumping plant, and distribution feeder mains.

2. Proportional cost of existing plant bought over past years and paid for by city consumers and now used and shared by the outside customers.

3. Special operational costs such as repumpage into these areas.

Allowance for these things may result in rates which may appear extremely high for these areas. How much of this is the central city justified in assuming of itself in order to maintain the economical needs for the continued growth of the central city as well as a metropolitan area? It must be recognized that city and suburbia are dependent upon each other to provide a balanced region in which are found factories, mercantile establishments, public utilities, highways, labor supply, housing, schools, transportation, recreation—all these essentials of balanced, gracious living. Modern developments make it impractical that all these can be found in essential abundance within the confines of the central city. The metropolitan area provides the balanced requirements; hence suburbia has developed through necessity and by choice.

Conclusion

Although this is today's philosophy, how about tomorrow's? Already, in the past few years, increasing evidence

has been discovered that more and more people have become disenchanted with commuting between the outer suburbs and offices and factories downtown. The "wide open spaces" have been narrowed by more and more people moving out to the country—too close for accepted comfort. Water and sewerage facility problems particularly have multiplied. On the other hand, many people do not like the hustle of the central city's streets for a regular diet, much preferring, in spite of some inconveniences, the relative quiet of a residential suburban area for their home life and the rearing of their children. They cannot contain a utopia, hence there is a growing unrest, which tends to forecast a higher development and concentration near the city's present limits. Economic development of these areas depends primarily upon population density. Wide and large residential lots or acreages do not tend to induce low service costs. It must be remembered that the economic development of many a central city was achieved through the prevalence of the 40- and 50-ft lot—not multiple-acre plots.

Hence, there is a developing water facility philosophy which recognizes the inevitable trend, one which includes economy of development with the desire for a balanced living condition. This has been intimated to portend a movement back from "suburbia" to "urbia." This will not occur overnight, but water utility men should recognize now its implications and include the thinking in their long-range planning.

Problems of Service Extensions to Fringe Areas

Joint Discussion

A joint discussion presented on Oct. 30, 1958, at the California Section Meeting, Los Angeles, Calif.

Municipally Owned Utilities—*William R. Seeger*

A paper presented by William R. Seeger, Gen. Mgr. & Chief Engr., Marin Municipal Water District, San Rafael, Calif.

THE problems of municipally owned utilities in service extensions to fringe areas are to some extent different from those of privately owned utilities. One reason for this difference in California is that independent companies are somewhat limited in their actions and policy determinations by the rules and regulations set forth by the State Public Utilities Commission, whereas municipally owned systems operate in accordance with the rules and regulations of the local governing bodies.

Providing water service to fringe areas presents a real administrative problem in municipalities because they become involved not only in basic intract main extensions but also in an off-tract problem. Any policy that tends to increase the cost of development is certain to be attacked by the local chamber of commerce and by real estate brokers. On the other hand, if the cost of bringing in a new water supply for the primary purpose of serving a fringe area is charged against the general operating costs, an increase in rates eventually may be required—at which time consumers may object to paying higher rates in order to serve these fringe areas. The problem of providing service to fringe areas, then, becomes one of who or what group should pay the expense and cost of developing fringe areas. As far as the operation of municipal systems is concerned, it is the responsibility of each of the governing bodies to set a policy that will be in conformity with the overall economy of the area they serve.

The first decision that must be made in reviewing the problem of serving water to fringe areas is what is meant by "fringe area." The exact definition of such a term will undoubtedly vary with the system to which it is applied, but, as an overall guide, a fringe area can be considered as that area lying within the city limits or district boundaries, as the case may be, which is outside or beyond the built-up area that is presently served or capable of being served from the existing distribution system.

Responsibility of Utility

The basic purpose of establishing a water utility, either privately or municipally owned, is to provide a means

of furnishing water to a specific area. Generally speaking, it is the responsibility of the utility to develop a sufficient and adequate water supply to serve the needs of its entire service area. It is not necessary that the complete system be built at one time; it can be constructed in accordance with the needs of the community. The second responsibility of the utility to the community is to transmit the water from its source to the general areas of use. From this point on it usually is for the individual applicant or developer to assume responsibility for the installation of distribution mains from the point of terminal storage to various areas being developed.

Although a municipality probably cannot refuse an application for service within its service area, the courts have held that it is within the power of the municipality to set the particular rules and regulations under which service will be given. The only requirement is that the rules and regulations be uniform throughout the area, and secondly, that they be reasonable.

Of special importance in considerations of the problem of service to fringe areas is the apparent legal obligation of a municipality to assume full responsibility for maintaining service to an area once service has been initially provided. It is of particular importance that new lines installed in fringe areas be large enough to meet future demands.

Typical Problem

According to the definition of a fringe area given above, it will be realized that existing distribution mains in a fringe area are of necessity operaing at maximum capacity and consequently cannot be extended without a reduction in service to the built-up area. Therefore, any service to a fringe area will require the installation of a new off-tract transmission line, extending from the nearest point of adequate supply to the fringe area in question. This, then, is the first major problem in furnishing a supply to a fringe area.

The first step is to convince the developer of the property that it is his responsibility to pay the cost of installing an off-tract transmission line. This problem, of course, can be eliminated if the utility agrees to pay the cost of any off-tract installation, but with such an agreement another more serious problem is unquestionably created—that is, to convince a city council or board of directors that the cost of off-tract installation should be paid for by the municipality.

If the policy of the municipality is such that the applicant is required to pay the full cost of installing the necessary off-tract line, the only direct responsibility that the developer has is to provide a transmission line of sufficient diameter to transmit an adequate supply for his development from the point of nearest supply to his tract. Unless the area under development extends all the way from the existing built-up area to the service area boundary, consideration must be given to the size of any new installation. This is necessary because the line must be of adequate size to serve the entire fringe area, even though the remaining property is under different ownership. This is one example of the important role that planning plays in the development of an overall water system. Proper attention to planning will go a long way in eliminating the fringe area problem.

If the proposed development lies directly adjacent to the developed area, the utility will be faced with the prob-

lem of installing a larger line to provide for future development beyond the present new extension, and if the new development lies beyond the present service area the line should provide enough capacity to serve the intervening area. If the developer is asked to pay for the larger pipe, he will immediately object that he is paying for supplying someone else's property—which, of course, is true. But, on the other hand, it is doubtful that a municipality could pay outright for the increased cost for a larger line, because real estate development, particularly in fringe areas, is considered a risk. For a municipality to pay money toward such a system would in effect be using public funds to install a line that might never return enough revenue to repay the investment. The utility is therefore at an impasse. The developer does not want to put up money to provide water to someone else's property and the city should not risk money on the venture.

Solutions

There are many methods of working out a solution, but it appears basically equitable that the initial developer should pay the full cost of a line sized adequately to serve the entire area opened up by the initial development; conversely, the developer should be able to obtain a refund to be applied toward the extra money paid by him for the larger line if the area develops and produces additional revenue in the future. This can be done in any one of three ways:

1. A special refund program can be devised whereby a percentage of the revenues derived from the developer's tract can be refunded over a period of years to repay the added cost of the larger line.

2. A special-assessment district can be organized whereby each parcel of property being served is assessed according to the benefit it derives. The assessed amount is paid to the initial developer at such time as the land is developed and the line is used to serve water to the parcels in question.

3. A special service connection charge can be determined which is payable at such time as the property requests service. This special connection charge is then paid to the initial developer to apply against his initial cost of installation.

Programs like those outlined above provide for the risk taken by the original applicant but make it possible for him to receive refunds to offset his initial capital expenditure for the larger line if and when the intervening area develops. The developer, of course, usually objects to the heavy cost burden placed on him. This is understandable, but he usually fails to consider the internal problems that the development of fringe areas creates, such as the necessity for additional water supplies to meet the increased demand, the necessity for larger transmission lines from the source of supply to terminal storage tanks, the required increase in terminal storage, and, in some instances, increased pumping capacity. In discussions on the cost of serving fringe areas, the developer usually argues that fringe areas bring more revenue to the utility, but actual experience has shown that, because of today's larger lots, the revenue per lineal foot of main is lower in fringe areas than on older, built-up systems, and the longer pipelines required to serve these large lots result in increased maintenance problems and costs. What this means, therefore, is that in fringe areas there are a reduc-

tion in the unit revenue received and an increase in maintenance costs.

Conclusion

This discussion has reviewed just one example of the problems that arise in the development of fringe areas. There are, of course, many other considerations, but the fringe area problem is usually related to economics and administration more than to engineering. Only through full and complete cooperation of the planner, accountant, and engineer, can a water utility hope to deal successfully with the fringe area problem.

Privately Owned Utilities—*Philip F. Walsh*

A paper presented by Philip F. Walsh, Vice-Pres., Southern California Water Co., Los Angeles, Calif.

Solving problems of water main extensions to fringe areas is one of the more important problems of water utility management today. Most of the solutions that have been found up to this time have usually been satisfactory neither to the utility, nor the developer, nor the public, nor the regulatory body. Much has been said and written about fringe area service in recent years. The avid interest shown by members of the water supply industry, whenever and wherever they gather, gives proof that the problems involved merit the careful consideration of water utility management. This discussion will be directed toward the problems of extensions to fringe areas by privately owned, state-regulated water utilities.

California is in an era of tremendous growth, both in housing and industry—an era of annexations to existing cities and incorporations of new cities. Urban boundary lines are being extended into areas that at one time were never considered susceptible to development. These annexations and incorporations are usually made with little regard to the economic and physical problems involved in rendering water service. Much subdividing has occurred in areas entirely divorced from improved areas. This is often the case where subdividers are able to purchase cheap land. Often this so-called cheap land is marginal, but great pressure is nevertheless brought to bear on the local water utility to provide domestic water service, as an inducement to prospective purchasers of real estate. Many large tract developments were never considered a part of the utility's service area in the initial design of the water system, and the subdivider who acquires and develops this land does so for only one purpose—to make a profit. It is certainly a question whether the water utility or its customers should, in effect, partially subsidize such development by providing water service at less than actual cost.

Utility Obligations

Unlike other businesses that serve the public, the utility has little or no choice in picking new customers. The privately owned water utility has an obligation to render service, usually provided for in its main extension rules and regulations, within its certificated area and contiguous areas. There are those who argue that a utility is a monopoly, that it therefore has a moral

obligation to extend its service to fringe areas, regardless of the conditions, either physical or economic. On the surface this appears to be a valid argument. In many fringe area developments, the physical burdens placed on the utility are obvious, and the economic problems are less obvious. The utility management must never lose sight of its obligation to its owners, the stockholders who furnish the capital, or to its present rate payers, whose rates are affected by the utility's investment in new facilities. These serious obligations make it incumbent on management to extend service only on a sound financial basis.

In a recent article (*1*), Jerome W. Milliman aptly pointed out: "Although it is often argued that: 'It is wrong to waste a single drop of our precious water,' the real waste, in a meaningful sense, occurs when the costs of providing water (or any other product) are greater than the returns from doing so." This is the root of the problem.

The ability of a particular plant to render service to a new area must always be considered, of course, but any responsible, qualified water supply engineer can design the required facilities to serve any fringe area from existing facilities by increasing the supply, the pumping and storage capacities, and the length, size, and number of transmission mains. The ultimate and basic question is who will pay, and how much. The problems of fringe area service are in the realm of economics not engineering.

Since the latter part of 1954, all of the privately owned water utilities in California have extended their services as provided for in a mandatory extension rule. It is not intended here to discuss the merits of this extension rule, but rather to point out some of the problems involved in extensions to fringe areas under its provisions.

Because the extension rule is mandatory for a privately owned water utility, there is less freedom of action in service to fringe areas than for the publicly owned utility. Because of the monopolistic character of all utilities, freedom from regulation appears to be dangerous. The public is entitled to regulation of utilities, although service to fringe areas by privately-owned utilities that operate under mandatory extension rules can sometimes have disastrous economic results.

Financing of Developments

All water systems are originally designed to serve a certain maximum number of customers. The tremendous population growth in California in the postwar years has taxed the ability of water facilities to serve the increasing number of fringe areas. Water supply has had to be increased, additional storage, booster facilities, and transmission mains have had to be built to insure adequate service to fringe areas. These facilities have been built with little, if any, financial help from the fringe area developers. The privately owned water utilities have, through their own ingenuity and resourcefulness, supplied the necessary new capital. Because only a small part of this new capital can be furnished from earnings and depreciation, there has been a constant quest for new sources of money for the privately-owned utility.

The larger, well established privately-owned utilities, which have long earnings and dividend records, have had little difficulty in raising this money through debt financing or sale of equity securities. The smaller utility, how-

ever, with an inadequate coverage, little or no dividend history, and insufficient bondable capital, continues to have great difficulty in raising capital.

Most of the insurance companies, which have provided a large portion of the bond money borrowed by smaller utilities to finance capital additions, do not look with favor on a long-term loan of less than $150,000. Short-term, bank financing at high interest rates usually is so prohibitive in cost that it offers little help. Loans from individuals are almost nonexistent. In addition, equity financing is practically impossible in today's competitive money markets when there is a lack of dividend history.

A considerable measure of relief was granted the privately owned water utilities by the new main extension rule which allowed a utility to include in the advance for construction not only the reasonable estimated cost of distribution mains, but also the reasonable estimated cost of service connections and fire hydrants. In addition, the refund requirement was reduced from 35 per cent of the gross revenues to 22 per cent annually, and the term of refund was extended from 10 to 20 years. This reduced the utilities' new-capital requirements within the subdivisions, but had one incidental effect on the utility, more serious particularly in the area of rapid growth: these utilities, serving an ever increasing number of fringe areas, have, in some cases, become topheavy with consumers' advances. The result has been an excessive ratio of debt to equity capital. The California Public Utilities Commission does not approve of an excessive ratio of debt to equity capital, and has, on occasion, spoken strongly on the subject with a recommendation that new capital be raised through the issuance and sale of common and preferred stock. Here again, the utility must face the problem of finding a market for equity securities.

The commission has allowed several utilities to convert portions of its advances for construction, by mutual consent with the developer, into preferred stock in the utility. This procedure, in effect, provides the utility with bondable additions of property for additional financing and relieves it of the annual cash refund requirement of 22 per cent of gross revenue. The value of the facilities is also included in the rate base. An incidental effect is that a higher ratio of equity capital to debt is provided, and the utility is in a better financial position and more apt to meet the capital ratio recommended by the commission.

With respect to new capital requirements, then, it may be said that service to fringe areas imposes a severe problem on privately owned water utilities in the raising of new capital not included in advances for construction. This problem can sometimes be so severe that the smaller utility overextends itself, service quality breaks down, and the customers, in their demand for better service, seek other alternatives. If this happens the utility has only one recourse—sale to either a larger private utility that is well financed and able to improve the service conditions or to a public body.

Rate Increases

It has been said that the only certain things in life are death and taxes. Equally inevitable are water rate increases. The constantly declining return on the services of privately owned water utilities is caused largely by: [1] increased operating and maintenance

expense occasioned by the inflationary spiral of labor and material costs, [2] inadequate depreciation reserve for the replacement of worn-out facilities, [3] construction of new facilities for service to fringe areas. All of these factors necessitate higher water rates.

Service to fringe areas is one of the main contributing factors to increased average investment, despite the main extension provision which allows the utility to require a subdivider to advance the estimated cost of facilities within the tract. The utility must provide—at today's high construction costs—the additional water supply, storage and booster facilities, transmission mains and meters. These represent an investment of 25–40 per cent of the advance made by the subdivider. This investment becomes part of the rate base. Refund payments on previous projects also are reflected in the rate base at the higher construction costs. This is partially offset by increased depreciation accrual. The 22 per cent-of-the-revenue method of refund reduces the increment of capital going into the rate base, but the proportionate-cost method of refund, whereby the subdivider receives his full advance on completion and occupancy of the house, aggravates the problem.

Service to fringe areas and its resulting effect on a utility's need for adjusted rates must be met squarely by the management of the privately owned utility. In these days of keen competitive utility service, no management desires increased rates, but it is the responsibility of a utility management to the company's owners to make sure that the rates provide a return that will service the debt, provide dividends to the investing public, and keep the utility in a sound enough financial position to attract new money.

Competition

Despite the generally accepted opinion that a utility is a monopoly, which it is by necessity, keen competition exists in fringe areas. Unlike gas and electric utilities, which depend upon one source of supply, usually transported from great distances and integrated into a massive distribution system serving a multitude of communities, the local water company is usually a small independent system depending upon ground water supply or purchase of wholesale water. As the source of supply is readily available, the private water utilities must compete for fringe area service, in areas not certified, with other private water utilities and publicly owned utilities. In some large developments, the subdivider considers the establishment of his own water utility during the course of development, with the ultimate view of disposing of the facilities at a handsome profit on the completion of the project. In this competition to serve fringe areas, many cities now served by privately owned water utilties have imposed a severe condition on approval of tract maps. This is done by ordinance, which requires that the subdivider, among other things, install and dedicate the water system to the city. Many of these cities do not have their own water departments but use this procedure as the first step toward establishing one. The privately owned utility, in order to maintain its position, has no recourse but to provide the water at wholesale rates to the city for resale to the home buyer. It is obvious in these instances, that if enough fringe areas are developed, the city, in its constant quest for additional funds, will

inevitably turn its attention to the local water company—a ready source of revenue that can be rather easily obtained by acquisition or condemnation. Recognizing the inherent right of eminent domain of a municipality and the ease of financing through revenue bonds, the privately owned water utility would have no other recourse but to negotiate the sale of its property to the city.

Taxation

There are two possible tax implications in service to fringe areas. Where there is fringe area subdivision into lots rather than mass housing, the advance for construction will obviously not be entirely refunded, because there will be insufficient revenues. The federal Internal Revenue Service has taken the position that unrefunded portions of this type of advance are not depreciable for income taxes. If this position prevails on all unrefunded advances for construction, the privately owned water utilities will be faced with a higher tax payment. Any increased operating cost will obviously have an effect on rates. For some other utilities, notably those providing television service from community lines, payment by customers for connection to the system has been considered taxable income in the year received. It has been reported that the Internal Revenue Service is now taking the same position on donations received by other utilities. It is conceivable that unrefunded portions of advances for construction for fringe area service could eventually be considered donations and, therefore, taxable income.

These tax implications must be considered by the privately owned water utilities in their economic analysis of the problems of fringe area service.

Summary

There are several important economic considerations in solving the problems of water main extensions to serve fringe areas. The first of these is financial. It has been pointed out that one of the more serious effects of main extensions to fringe areas is the difficulty for the smaller utility to raise the new capital required for so-called backup facilities. One method of easing this problem is to convert advances for construction into preferred stock. This procedure has the advantage of increasing the rate base, satisfying the recommended equity ratio of the utility's capitalization, and in many cases providing bondable additions of property. In addition, the utility is relieved of paying annual cash refunds, although this is offset to some degree by the payment of dividends. One other method of solving the problem of new capital is the merger of smaller utilities, which has the effect of providing more bondable capital for the merged companies and economical operation owing to size. It is fundamental that every management skill available must be utilized to maintain a healthy financial position and attract the new money required to provide the necessary facilities to serve fringe areas.

In the matter of rates, the provocative problem is whether service to fringe areas should affect the rates of the present customers of a utility. Under the provisions of the present California main extension rule, rates are eventually affected. Because of public resistance to increased rates for any reason, adverse public relations result. Water rates are just as competitive in the market of today as are prices of other goods. One solution to the problem of rate increases due to

service to fringe areas is a main extension rule based on a cost-to-revenue principle. It appears valid and logical that a utility earning a fair rate of return on an established customer rate base should not be called upon to invest more than this average capital to serve a new customer. Although this principle limits the refund to a subdivider, the utility should only have to refund that portion of an advance that would be adequately supported by a fair return from the revenues developed. This procedure would tend to stabilize the rate base and protect the present customer. There are those who dispute the validity of making any refunds to subdividers. If utilities must, then, adhere to the historical policy of refunds, should they be paid to the subdivider who has long been conditioned to installing water distribution systems in municipalities and dedicating these facilities without any refund? This policy has little noticeable effect on the price of houses compared to their price where refunds are paid. As a matter of fact, refunds from the water utility provide the subdivider with additional income for a long time *after* the project is completed and his profit has been made. Should not these refunds be paid to the person who is actually financing the water system—the home buyer? In these days of critical public relations, what could be better for public relations than having a home buyer, shortly after he occupies his new home, receive a letter informing him that he will receive an annual refund on his water bill until such time as the pro rata share of the water system in his new tract, which he paid for in the price of his house, has been entirely refunded to him. The home buyer would, in effect, become a stockholder in the utility, and would be an important factor in the promotion of good community relations.

Competition exists among utilities for service to fringe areas. The privately owned water utility cannot compete with ordinance, but it can develop the free-enterprise philosophy of utility service if it maintains superior service and reasonable rates. No public ownership of the local utility can be effective unless it meets the practical tests of better and more economical service.

The tax implications of fringe area service may result in additional costs in rendering the service. These costs have to be considered in the economic analysis of fringe area service.

Service to fringe areas presents many problems, all of which can be solved by an intelligent application of sound economic principles. Service to fringe areas also offers many opportunities.

Acknowledgment

Appreciation is expressed to colleagues in the industry with whom the author has discussed the subject of service to fringe areas many times, and particularly to W. C. Welmon, of the Southern California Water Co., who offered much help and advice in the preparation of this article.

Reference

1. Milliman, Jerome W. Economic Aspects of Public Water Utility Construction. *Jour. AWWA*, **50**:839 (Jul. 1958).

Use of Microstrainer Unit at Denver

George J. Turre

A paper presented on Sep. 16, 1958, at the Rocky Mountain Section Meeting, Denver, Colo., by George J. Turre, San. Engr., Bd. of Water Commrs., Denver, Colo.

MICROSTRAINING is a form of simple filtration. Its object is the clarification of liquids by filtering out a large portion of the suspended matter present in water supplies or, in some applications, sewage effluents. Microstrainer units are now in use in Canada, Great Britain, and elsewhere.

On Jun. 24, 1958, a microstrainer unit* (Fig. 1) was installed at the Marston Lake South Side Filter Plant, for the purpose of removing microorganisms (algae and suspended material) present in Marston Lake water. Figure 2 is four microphotographs of microscopic organisms, mostly plankton, found in a sample of wash water discharge from the microstraining installation. Some of the organisms removed are shown in Fig. 2 and listed in Table 1. Organisms not shown in the microphotographs, such as planktonic crustacea, and other microscopic debris, are readily removed by the microstraining process.

When the photomicrographs were made, the temperature of Marston Lake water was 66°F. When the temperature increases to 70–72°F other types of algal infestation may be expected, such as the Chlorophyceae (green algae) and the Cyanophyceae (blue-green) group (Anabaena and Aphanizomenon). These two groups have given trouble in the past. No difficulty is anticipated in removing them from the water by microstraining.

Construction of Unit

The microstraining unit is mounted in and on a rectangular steel tank, 13 ft × 11½ ft × 7½ ft. The steel tank is divided into a small raw-water chamber located at one end, and a strained-water chamber. A rotating drum unit, 7½ ft in diameter and 5 ft long, is located in the strained-water chamber. The drum is about three-fifths submerged in water, with the unstrained water on the inside of the drum. The drum is driven by an electric motor directly connected to a

TABLE 1

Some Organisms Removed in Microstraining With Mark O Fabric

Algae	Diatoms
Pediastrum	*Asterionella*
Staurastrum	*Fragillaria*
Crustacea	*Melosira*
Cyclops	*Navicula*
Protozoa	*Nitzchia*
Mallomonas	*Stephanodiscus*
Ceratium	*Surirella*
Rotifera	*Synedra-Pulchella*
Anurea	*Synedra-Ulna*

* This unit was manufactured in Kilmarnock, Scotland, and supplied by Glenfield & Kennedy, Inc., New Rochelle, N.Y.

variable-speed reduction gear. Speeds of the drum can be varied from 0.5 rpm to 4.0 rpm. The correct speed at which to run the drum will vary, depending upon the quality of water to be handled. The Denver unit operates at present on 2 rpm. The microstraining unit has been rated at 2 mgd, but 3.9 mgd has actually been obtained with raw water of 3.0 ppm turbidity, which is an excellent raw water.

The revolving drum is constructed of cast bronze, monel, and stainless steel. The stationary end frames for the drum are made of the best-quality gray cast iron. The periphery of the drum is covered with a fine stainless-steel cloth. This microstraining fabric has 160,000 openings per square inch, with size as small as 23 μ (approximately 0.001 in.). The stainless-steel cloth is overlaid with an 8-mesh, stainless-steel screen for support. The fabric and the 8-mesh, stainless-steel screen are securely fastened at each end of the drum, so as to leave a 5-ft length of the fabric exposed to the water. At each end of the drum, a copper band backed by impregnated felt extends around the circumference for the purpose of preventing leakage between the drum and endplates. The band assembly is similar to an automobile brake lining. Adjustments are provided for tightening the bands when necessary. The downstream end of the drum is closed and supported by a lubricated stainless-steel bearing in the endplate. The upstream end is fitted with a spoked ring and stainless-steel trunion bearing on the drum axis. The spaces between the spokes form the inlet to the drum.

The water to be strained enters the drum axially and flows radially through the fabric. The loss of head from the inlet to the outlet is due almost entirely to passage through the fabric and is rarely allowed to exceed 5–6 in.

Inside the drum is a wash water hopper. The hopper is attached to the hollow axle of the drum and drains into it. Wash water passes through the center of the bearing located on the upstream side of the unit.

Fig. 1. Microstraining Unit During Installation in Tank

This is the unit being lowered into the tank. The upstream endplate is at the left.

Washing

The cleaning arrangement consists of a row of jets at the top, outside of

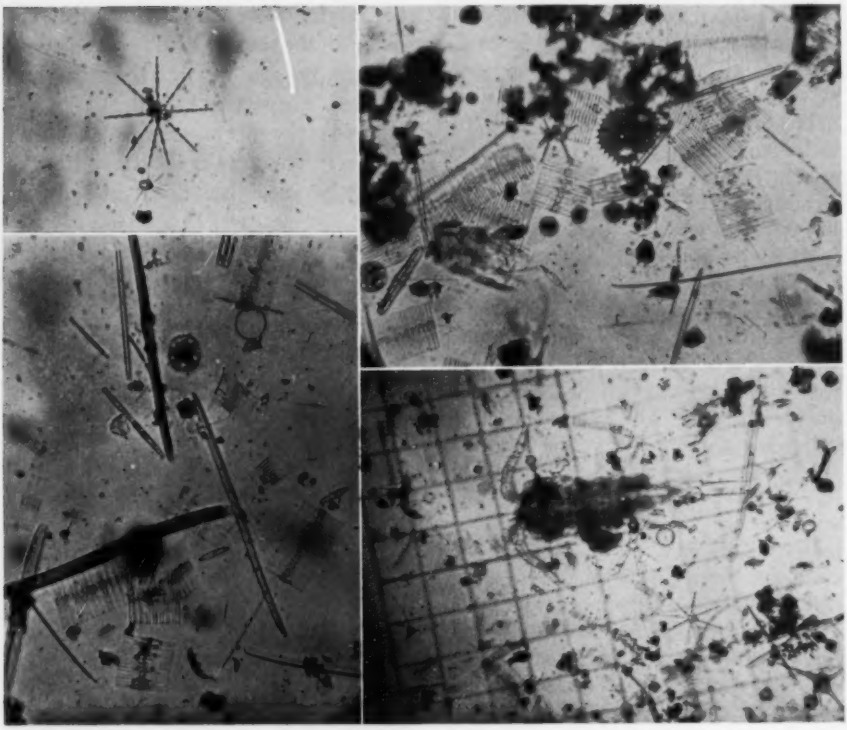

Fig. 2. Microorganisms Removed by Straining Unit

The microorganisms shown above are listed in Table 1. The microphotographs are 100×.

the drum. The jets penetrate the microstraining fabric and flush the solids from the fabric into the wash water trough, from which the material is piped through the hollow axle to waste. Longitudinal lifter bars inside the drum pick up and deposit into the wash water trough any solids that do not adhere to the fabric. The jet nozzles have fine slots and are self-cleaning. They are arranged to give almost a continuous vane of water across the fabric. A plastic shield is provided over the wash water jets to prevent wash water from splashing over the machine. Inlet water and wash water are metered. A pressure gage is inserted in the wash water service. In the short time the microstrainer has been under test at Marston Lake, the percentage of wash water used has been surprisingly low.

Operation Record

Daily tests are being made in the laboratory of the Denver water department for identification of organisms removed, percentage removal, and tur-

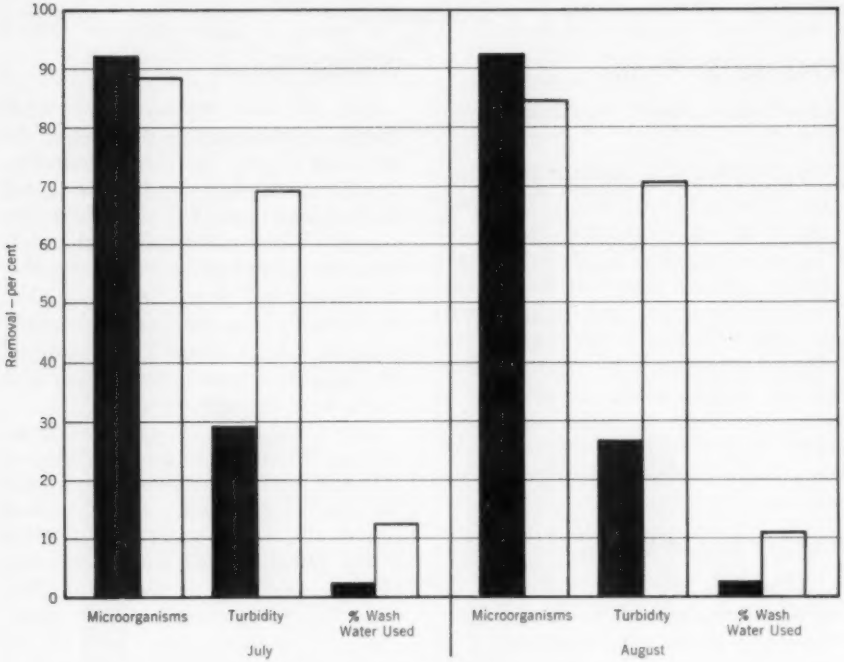

Fig. 3. Comparison of Microstraining and Filtration, July–August 1958

The solid bars represent data for the microstraining unit. Open bars represent filtration.

bidity removal. Daily records of the percentage of wash water used, water strained, pressure of wash, and head loss are made at the installation site. The results obtained so far from laboratory tests and operational data have been very encouraging, and have demonstrated the effectiveness of this kind of equipment in the removal of suspended solids, especially the microscopic organisms. Figure 3 is a comparison of the effectiveness of microstraining versus filtration in removal of turbidity and microorganisms and wash water used for the months of July and August 1958. When more time has passed and the unit has been subjected to more extreme conditions, sufficient data should be available for a more complete evaluation.

Discussion

George R. Evans

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The author has supplied the writer with some additional data on the operation of the microstraining unit at the Denver Water Board's Marston Lake supply. These data will be included in this discussion and indicate that the same high level of performance was maintained through the months of September and October. In addition, it seems pertinent to make some additional comments, using the same headings as presented in George Turre's article.

Construction of Unit

Allowable flow ratings through the fabrics vary up to about 30 gpm/sq ft, depending on the particular fabric used —that is, on the size of the openings— and on the concentration of particles in the raw water. For this reason, arbitrary flow ratings cannot be adopted for specific capacities in designing microstraining units; rather, it is necessary to design capacities using the concept of filtrability of fluids (*1*).

The filtrability index, volume of flow, rotational speed of drum, area of fabric, and loss of head through the fabric are all interrelated in the selection of the most economical size and number of machines for any particular installation.

The filtrability index is a measure of the rate of blinding which will occur in the fabric. The maximum rate at which a fabric blinds under a head differential, so that breakthrough of the mat does not occur, determines the size of the installation for a given flow.

Washing Process

The requisite pressure for wash water varies with: [1] the load in the incoming supply (as demonstrated by the filtrability index); [2] the speed of the drum; and [3] the fabric employed. Wash water consumption has been the subject of close investigation at Denver, and from figures supplied by Kenneth Day, the board's filtration engineer, the average gross metered pumpage for 4 months was 1.7 per cent of the flow through the unit.

The actual quantity wasted is measured at Denver by timing the filling of a 50-gal drum; it amounted to a little less than 1 per cent. For the same period the wash water consumption at the Denver South Side Plant was 11.4 per cent and at the North Side Filter Plant 3.2 per cent. These microstraining results correspond to recorded data from other installations such as Bristol, England, and Auckland, New Zealand, which give 1.1 per cent and 1.0 per cent, respectively.

The wash water pressure, normally 18–20 psi, was increased to 22 psi during a period of heavy aquatic growth at Denver in October. Pressures up to 35 psi have been used for short periods to combat exceptional loads in other installations, particularly for treatment of sewage effluents, but much lower pressures are usually adequate for normal running.

During periods of heavy blooms, the fabric can become partially blinded by overloading and, sometimes, by bacterial slimes or slimes spread by certain types of algae. The use of wash water pressures that are too low can produce the same effect. This situation necessitates occasional cleaning

with a 12–15 per cent sodium hypochlorite solution, which is easily effected with a minimum of interruption. The frequency of such treatment varies with the amount and type of organisms and the wash water pressures employed.

This fact was borne out by experience at Denver. There, hypochlorite treatment was necessary about every 40 days in the summer when *Asterionella* predominated, but at the time of a heavier growth of different types in October—and slightly higher wash water pressure (22 psi)—the fabric remained quite clean. Similarly, the installation for the Alaska Pine & Cellulose Co. at Port Alice, B.C., successfully withstood a heavy invasion of fresh-water shrimp (copepoda) early in 1958. A temporary increase in wash water pressure and a single hypochlorite treatment ensured a continuous supply.

The hypochlorite treatment is the sole item of upkeep to date at Denver and in fact the installations at Bonner, Mont., and Port Alice, B.C., have had similar records for more than a year.

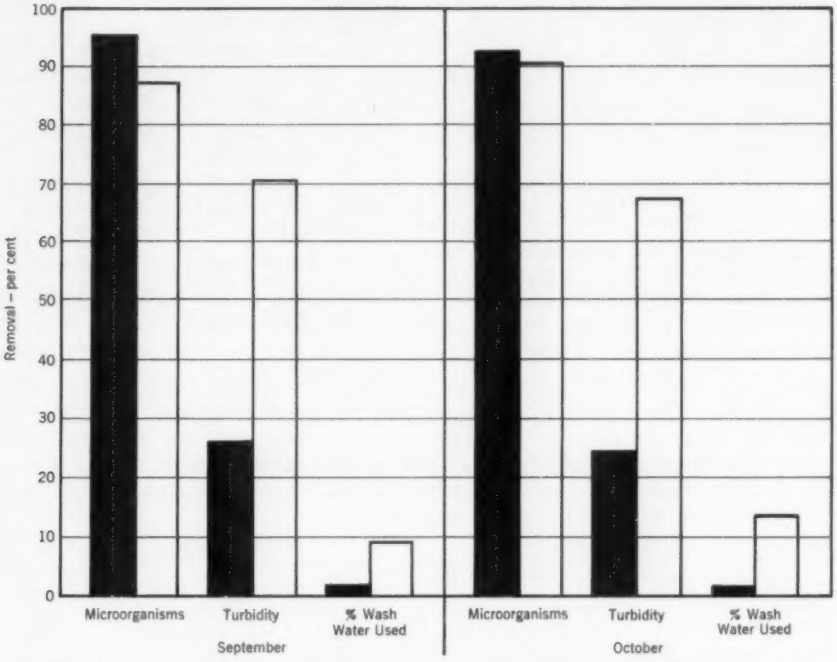

Fig. 4. Comparison of Microstraining and Filtration, September–October 1958

The solid bars represent data for the microstrainer unit; open bars represent filtration.

Operation Results

The author presented the operating data in bar graph form in Fig. 3 for July–August 1958. He has also assembled the data for September–October in the same form and these

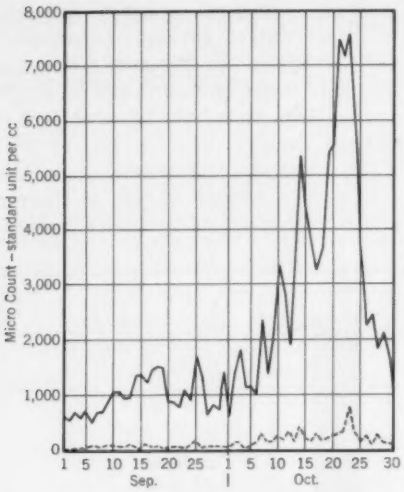

Fig. 5. Removal of Microorganisms in Marston Lake Water, September–October 1958

The solid and dashed curves represent counts in raw and strained water, respectively.

data are shown in Fig. 4. Data for these two months are also shown in line graphs in Fig. 5 and 6, which clearly indicate the high quality of the finished water after microstraining.

During October the algal growth rose to 7,500 areal units and some blue-green species were encountered (notably *Anabena* and *Aphanizamenon*), but only once did the effluent have an organism count of over 500 areal units. Turbidity was usually less than 3 ppm; on only one occasion did it rise to 4 ppm.

During the time of high count in October the flow through the unit was recorded as 3.2 mgd and the drum speed was increased to 3 rpm. Although some rise in the organism count could be expected under conditions of heavy growth, the count in the finished water would have been lower if the drum speed had been kept at 2 rpm. At this slower drum speed, however, the flow would have been reduced and the percentage of wash water consumption slightly increased. The 2-mgd design capacity was a preliminary estimate intended to cover most of the conditions that were likely to occur, including heavier growths than those encountered so far.

The recent experience of the Belleville (Ont.) Utilities Commission might be quoted in this connection. Four microstraining units (Fig. 7) using Mark I fabric (apertures of 35 μ) were recently installed ahead of existing rapid sand filters, to treat a supply that comes from the Bay of Quinte, Lake Ontario. This water is subject to heavy algal growths, which reduced filter runs in August 1957 to as little as 2 hr, with an average of only 9.9 hr for that month. The count during the same period for 1958 was nearly double that for 1957 and was the heaviest growth for some years. Under these conditions the flow

TABLE 2

Comparison of Microstrained and Filtered Marston Lake Water, July–October, 1958

Month	Process	Microorganism Reduction *per cent*	Turbidity Reduction *per cent*	Wash Water Used *per cent*
Jul.	Microstraining	91.1	29.3	1.74
	Filtration	88.1	69.1	12.60
Aug.	Microstraining	92.6	26.3	1.77
	Filtration	84.2	70.7	10.70
Sep.	Microstraining	95.3	25.8	1.78
	Filtration	87.2	69.9	9.20
Oct.	Microstraining	93.1	24.4	1.60
	Filtration	91.6	67.8	13.11
Avg	Microstraining	93.0	26.5	1.7
	Filtration	87.7	69.5	11.4

through the straining units was reduced to 1.5 mgd per 7½-ft machine for a short period. The supply was, however, maintained without interruption and the minimum run for August 1958 was 21 hr, the average being 50.6 hr. The microorganisms encountered were *Melosira, Asterionella, Fragilaria, Tahillaria, Microcystis,* and *Anabena.*

If such extreme circumstances are to be met, the design must be changed accordingly with resultant increase in cost. For obvious reasons, microstraining installations are normally designed for something less than the worst conditions known or anticipated, of all kinds is filtered out, no appreciable reduction of true colloidal matter, of color in solution, or of bacteria can be expected by microstraining.

With heavier loads of different material, removals are greater than noted at Denver. For example, in central Africa, where the Tanganyika Public Works Department supplied figures showing reductions (by microstraining) of suspended solids in the Morogoro River, removal was 86 per cent—from 39.5 ppm in the raw water to 5.4 ppm in the strainer effluent. Also at Christchurch, England, at an installation supplying a petroleum refinery,

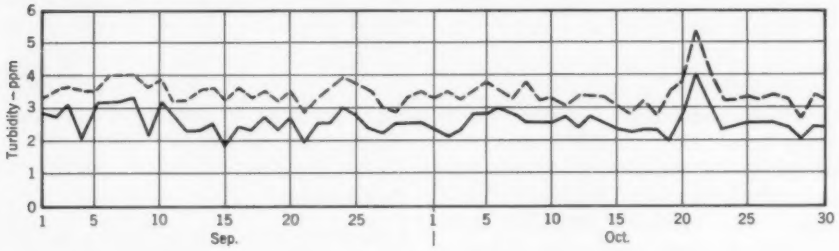

Fig. 6. Removal of Turbidity in Marston Lake Water, September–October 1958

The solid and dashed curves represent turbidity in strained and raw water, respectively.

after all data in the form of filtrability indexes, local knowledge of varying water conditions, and operating experience have been taken into account.

Table 2 shows the average removals of microorganisms and turbidity recorded at Denver for the 4 months, July–October 1958. From this table it can be seen that the removal of microorganisms was excellent. As expected, the reduction in turbidity was not high, because the original amounts in the raw water were small and the material was largely colloidal. As has been pointed out previously (*2, 3*), although suspended microscopic matter reductions in solids of over 62 per cent have been reported with raw River Avon water that has a content of up to 70 ppm.

At Bonner, Mont., although no actual figures are available for suspended-solids reduction, the microstraining unit has successfully protected high-head (1,800 psi) pumps from erosion by solids in the supply from the Blackfoot River.

Applications

Installations in operation and under construction now total nearly 100. There is an erroneous impression that

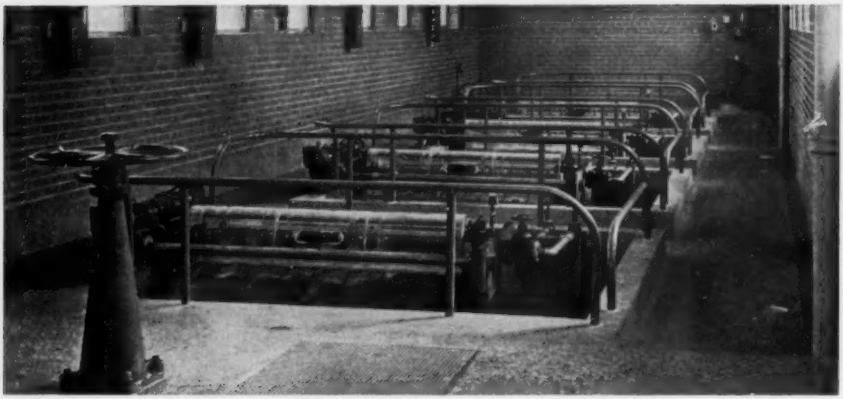

Fig. 7. Microstrainer Installation at Belleville, Ont.

These four microstrainer units are installed ahead of rapid sand filters and have been effective in removing the heavy algal growth to which the Bay of Quinte, Lake Ontario, is subject.

the most common use for microstraining is before slow sand filtration. Although it is true that a greater proportion of the early installations, and many presently being installed, were for that purpose, it is also true that over the last few years microstraining, as the sole filtration process, has been the principal application in both public and industrial supplies. An increasing number of microstraining units are also being used for effecting primary treatment ahead of rapid sand filters in a manner similar to installations in front of slow sand filters.

References

1. BOUCHER, P. L. Microstraining and Its Applications. *J. NEWWA*, **70**:1 (Mar. 1956).
2. EVANS, G. R. Review of Experiences with Microstraining Installations. *Jour. AWWA*, **49**:541 (1957).
3. HAZEN, RICHARD. Application of the Microstrainer to Water Treatment in Great Britain. *Jour. AWWA*, **45**:723 (Jul. 1953).

Asiatic Clams as Potential Pests in California Water Supplies

William M. Ingram

A contribution to the Journal by William M. Ingram, Biologist, Robert A. Taft. San. Eng. Center, USPHS, Cincinnati, Ohio.

DIFFICULTIES caused by Asiatic clams, *Corbicula fluminea* (Muller) (Fig. 1), in California irrigation systems have been reported. These organisms have been troublesome in the Coachella Valley in Southern California and at the Tracy Pumping Station in central California. Concern has also been expressed by the Metropolitan Water District of Southern California, which has not yet encountered problems but has foreseen possible clam difficulties. With further development of irrigation and potable water supplies, Asiatic clams are seen as potential pests and a threat of continuing nuisance by those who are charged with maintenance of water projects.

Distribution

These clams have been found well established in natural waters where present nominal uses have not yet brought them into intimate contact with man. The Asiatic clam was reported in North America in 1948 (*1*). From collections then available, the Asiatic clam was listed as occurring in California at the following localities: the north end of Sherman Island at north end of Mayberry cut in the "Old Sand Bank," Sacramento County; Frank's Tract near Oakley, junction of Broad Slough and the Sacramento River, near the mouth of the Mokelumne River; the Sacramento River near Isleton; Shad Landing, San Joaquin River; the Middle River at Santa Fe Railroad Ferry, San Joaquin County; Snodgrass Slough; and a drainage ditch into Sycamore Slough near Reveal Landing, South Fork of the Mokelumne River, San Joaquin County. California localities subsequently reported to the author are: the Colorado River Aqueduct near Gene Pumping Plant; Mecca from an irrigation outflow channel discharging into the Salton Sea; Rock Slough, Contra Costa County; an irrigation ditch 12 mi east of Los Banos, Merced County; vicinity of Bakersfield, Kern County; San Joaquin River as far as Patterson; Antioch to the Feather River; the Contra Costa and Delta-Mendota canals of the California Central Valley Project; and Modesto, Tuolumne River, Stanislaus County.

In 1948 the clam was also found in the Columbia River in Pacific County, Wash., and in the Willamette River, Ore. Present information is that clams are being taken from Lake Mead on the Colorado River, and from water supplies of Phoenix, Ariz. In the US National Museum the author has examined two specimens from Phoenix which bear the accession date of Nov. 18, 1954. In 1958 Dundee and Dundee (*10*) reported the Asiatic clam

from an irrigation canal behind the Desert Plant Botanical Garden (Papago Park) in Phoenix, Ariz. They refer to earlier records of its distribution in the West based on mimeographed minutes of the Conchological Club of Southern California. In the Pacific Northwest, recent information

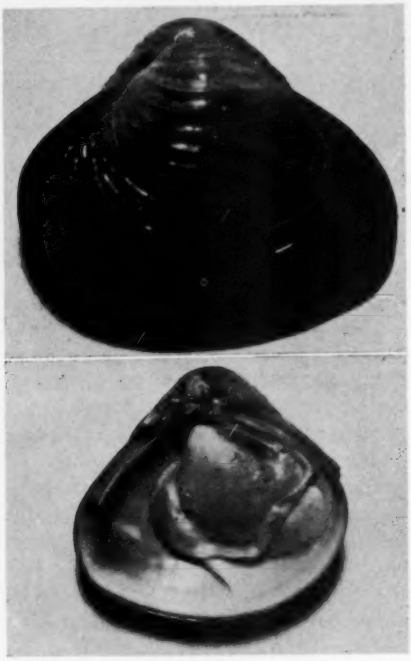

Fig. 1. Asiatic Clam

The actual length of this specimen was approximately 31 mm. Upper photograph, exterior view; lower, interior view.

states that clams occur on both the Oregon and Washington sides of the Columbia River at Bonneville, and in the Snake River on the Washington–Idaho border. The earliest collection date for California specimens available to the author is 1946, where they were found in an irrigation ditch 1.6 mi east and 2.2 mi north of a road crossing over Potato Slough at Terminus on Lodi-Isleton Highway. The earliest collection date from Washington is 1938 in the Columbia River, 2 mi east of Knappton. The specimens bearing these dates are housed in the California Academy of Sciences.

Information is still not available to indicate how widely the Asiatic clam is distributed in the Western States, although it is 10 years since their presence was recorded in published literature (*1*). This article establishes this clam as an economic pest, and water development agencies may therefore wish to investigate thoroughly its distribution lest it become related pestiferously to planned projects.

Nuisance in Coachella Valley

In 1953 C. S. Hale, general manager of the Coachella Valley County Water District, Coachella, Calif., stated in correspondence that an apparently serious infestation of *Corbicula fluminea* had developed in the water district's underground distribution system. Irrigation water is taken from the Colorado River at Imperial Dam, transported through 123 mi of open canal, and distributed through approximately 500 mi of underground pipe. Accumulation of live clams and clam shells causes serious impairment of water delivery at farmers' turnout valves, at ends of laterals, and in irrigation sprinkler systems. Clams were appearing in irrigation water in Riverside County and Imperial Valley distribution systems.

Further correspondence with Hale in March 1955, stated that the clam population had greatly subsided in the summer of 1954, and that there had been little trouble as compared to 1953.

No explanation was offered for the subsidence, except that water temperatures had probably been a little higher. In 1954, owing to weed debris, most of the canal water was diverted to a settling basin about 2 mi long. From this basin the water was returned to the canal at a somewhat higher temperature, which resulted from the shallowness of the basin.

In January 1958, correspondence from Lowell O. Weeks, general manager and chief engineer of the Coachella Valley County Water District, reviewed the troubles cited in Hale's letters and brought the clam situation up to date. Weeks stated that an 8-ft diameter lateral is opened each January at its distribution point. In 1953, perhaps 100–200 clams were found in this structure. In 1954 about 3 cu yd of clams were removed, but during the summer the clam nuisance to farmers greatly subsided. In January 1955 only about ½ cu yd had accumulated in the lateral. Succeeding seasons have revealed only slight accumulations in this structure and no farmers have complained. Weeks commented that 86 mi of unlined canal, which brings water into the Coachella Valley from the All-American Canal, was emptied of water in November 1957 after approximately 10 years of continuous flow. It was noted that various sections were heavily infested with clams, and that for a distance of ½ mi the bottom appeared to be heavily graveled with clams. This observation led him to believe that recurrence of the 1953 summer clam infestation was entirely possible if and when the correct conditions occurred. No control measures were mentioned in the correspondence, other than manual removal of clams. The single explanation proffered for the subsidence of clam nuisances was the 1954 diversion of canal water into the settling basin, where increased water temperature may have reduced clam populations.

Metropolitan Water District

In January 1958, Lee Streicher, chief chemist of the Metropolitan Water District of Southern California, stationed at LaVerne, Calif., wrote that an infestation of fresh-water clams had recently been discovered in Colorado River water near the intake of the district's aqueduct system. These clams were identified as *Corbicula fluminea*. Specimens sent to the author were collected on Dec. 14 from the Colorado River aqueduct near Gene Pumping Plant. No trouble was then reported as being caused by the clam, but concern was expressed as to the possible effects on the carrying capacity of pipelines and possible damage to the impellers of large centrifugal pumps, should the clams be dislodged from the invert of the pipe and drawn into the pumps.

The experience of the Coachella Valley County Water District has demonstrated that the Asiatic clam can disrupt flow through pipe. With time, large accumulations of shells could also affect flow in large pipe, if the 3 cu yd of clams that accumulated in the 8-ft lateral of the Coachella irrigation system represented the annual volume entering into large distribution pipe. Difficulties that are caused by the fresh-water, zebra clam, *Dreissensia polymorpha*, in reducing the diameter of 24-in. mains in England have been described by Clarke (*2*) and summarized by the author (*3*). Fortunately, this clam is not found in the United States. Once established in mains and pipe, it would be harder to

remove than the Asiatic clam, as it has a holdfast by which it attaches itself.

One can surmize that pump impeller troubles could result from pumping clams, 31 mm long, 25 mm tall, 15 mm broad, and weighing 3–6 g. The hard, calcium carbonate shell covered with chitin makes the adult clam quite durable. If shells of dead clams, especially

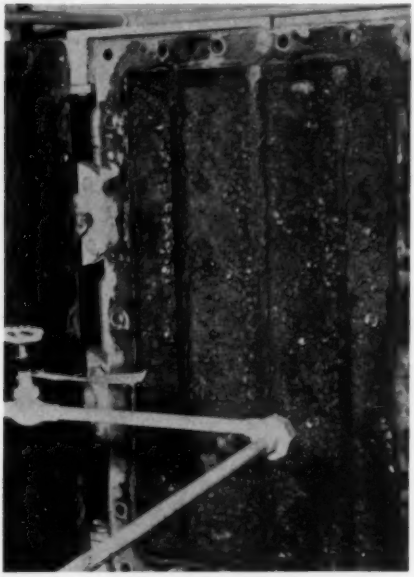

Fig. 2. Clam Infestation of Condenser–Cooler Unit

Lodging of clams such as is shown here has presented a great problem at Tracy Pumping Station, Sacramento, Calif.

from the small, immature clams with fragile shells, become fragmented, abrasion of pumps can result. One instance of such abrasion in piston-type sludge pumps by shells of a small type of mollusk has been pointed out (*7*).

Some experimental work, using jar tests to determine the molluscacidal action of copper sulfate and chlorine were carried out by Streicher. It was determined that the combined molluscacidal action of chlorine and copper sulfate was more effective than either alone.

Tracy Pumping Plant

Correspondence in March 1958, forwarded by B. P. Bellport, regional director of Region 2 of the Bureau of Reclamation in Sacramento, Calif., vividly described troubles caused by Asiatic clams at the bureau's Tracy Pumping Station. The material was assembled by H. W. Thomson, chief of the Tracy operations field branch. The main strainers at the pumping station have sometimes required hourly cleaning, owing to the presence of clams. Clams also plug the tubes of the synchronous condenser–cooler units.

The main-line strainers have ¾-in. openings and the heat exchanger tubes are $\frac{5}{8}$ in. in diameter. Small claims pass through the strainers, and lodge in the system ahead of the cooler units (Fig. 2), where they increase in size. They are later dislodged, but some are too large to pass through the heat exchanger tubes (Fig. 3).

Molluscacides

A search in 1952 for a molluscacide for clam control indicated that copper sulfate was effective at a 750-ppm concentration with an exposure time of 48 hr. Chlorine was found to give a quicker kill, but the required concentration was corrosive to metal.* In 1953, 2,500 ppm of a relatively inexpensive aromatic solvent was found

* It should also be pointed out that use of copper salts in high dosage will also corrode iron structures.

to be effective and stated to be safe. The present control method is to inject approximately 2,500 ppm of coal-tar naphtha plus an emulsifier into one of the 600-gpm pumps supplying water to the condenser–cooler units until the effluent becomes discolored. The water is then shut off for 24 hr, after which time the unit is flushed at increased velocity using two 600-gpm pumps. The cooler unit heads are then removed and the plugged tubes are cleaned. With this treatment and with use of both pumps in normal operation, the clam control problem in the condenser cooler system has been reduced. Chemical treatment is done in September or October when the condensers can be shut down, but these months are not necessarily the best time of year for effective clam control.

Fig. 3. Clams Removed From Condenser Cooler Unit at Tracy Pumping Station

Clams such as these are too large to pass through the heat exchanger tubes of the cooler and thus lodge and clog the unit (Fig. 2).

Further, it is reported by the Bureau of Reclamation that, after use of copper sulfate for algal control in the Contra Costa Canal, clams and snails contribute to taste and odors in water; also, that clams are undesirable inhabitants in the Delta-Mendota Canal, where they form deposits in the quiescent water of the canal curves, in turnout recesses, and in irrigation boxes.

Habitat and Life Cycle

Corbicula fluminea apparently does well in substrates of sand, or mud, or a combination of the two. A 1958 report (*4*) indicates that in rivers in the vicinity of Taipei, Taiwan, this species prefers a sandy bottom to a silty one. It also appears to prefer a fresh-water habitat. Some species prefer marine habitats, and others show preference for brackish water.

Individual clams bury themselves in the substrate with the posterior end of the shell extending upward into the water to expose the siphons. Microorganisms are drawn into the mantle cavity through the incurrent siphon and eventually enter the mouth where they pass into the digestive system. Solid wastes are extruded from the anal opening and pass out into the water through the excurrent siphon.

The literature is in disagreement on whether Corbicula clams are hermaphroditic or dioecious (*4, 9*). Fertilized eggs develop and hatch in the adult clam. Free-swimming, microscopic larvae are released into the water. A few thousand may be released by a single clam.

Correspondence received from L. O. Weeks of the Coachella Valley County Water District includes data collected by the California Department of Fish and Game relative to clam larvae and states: "Invisible, free-swimming larvae may be in such numbers as to

count out 400 per cubic inch of irrigation water." These would be small enough to pass through standard strainers of water meters. Thus, if growth conditions are favorable, the larvae can develop into juvenile or adult clams at almost any point in an irrigation or potable-water supply system. The author has no data that indicate the exact duration of the spawning season for *Corbicula fluminea* on the West Coast. In Taiwan, June through September appears to be the period when spawning occurs and eggs are most numerous (*4*). The duration of the larval stage is not known.

When C. E. Warren, of Oregon State College, studied *Corbicula fluminea* in the Tuolumne River, Modesto, Calif., in 1952–53 he wrote that he had found individual clams of about 1 mm in diameter in considerable numbers from April through October. Such small-sized individual clams distributed over this period indicates a long period of spawning. He observed that a 50-mm length was close to the maximum size reached by this species in the Tuolumne River and hypothesized, from the number of dark shell bands, that clams may reach this length during their seventh summer. The shell erosion noted on 50-mm clams may limit the age to which this species can attain. The largest shells reported from Canton by Prashad were 83 mm long, 77 mm high and 50 mm thick (*8*).

Elimination of Mollusks

Even though chemical treatment may result in successful kills, physical measures must be employed to eliminate Asiatic clam from channels and pipe. The vulnerable link in the life cycle of this clam is the free-swimming larval stage when the young are protected by no shell, or by a poorly developed one, at best, into which the body cannot be withdrawn. Thus, if the spawning seasons for this clam are determined, chemical control measures can be most effectively directed at the naked larvae. As spawning may be triggered by changes in temperature, this period in central California may vary from that in the Coachella Valley, and both of these times vary from Oregon and Washington spawning.

Jar tests on both larvae and adults can determine molluscacidal efficiencies in relation to the strength of compounds and contact time necessary for complete kills. Where drinking-water supplies may be involved, chlorine and certain copper compounds, such as copper sulfate, are the only chemicals recommended by current water treatment practice that could be put to use as molluscacides. The recommended limitation on the use of the latter is delineated by USPHS (*5*) which states that in treated waters copper as Cu should not exceed 3 ppm.

At present too little is known about the toxicities of the newer molluscacides, such as sodium pentachlorophenate (*6*), to think of using them for prophylactic treatment or eradication of mollusks in finished water. Complete information is not at hand to indicate what the toxicity of this compound and others would be to crops or animals that are watered by irrigation supplies.

With the threat of the extension of the Asiatic clam in present and future water development projects, it certainly behooves the administrators of such projects to obtain accurate data on the effectiveness of available molluscacides on larvae and adults. Of greater importance is the simultaneous determination of the presence or lack of toxicity to humans, domestic ani-

mals, fish, and plants that would be intimately contacted by irrigation waters.

Nomenclature and Foreign Distribution

Prashad (*8*), who has extensively studied the various species of clams of the genus *Corbicula,* states that *Corbicula fluminea* has a wide range in southeastern China and Korea, and is also found in the Ussuri Basin in southeastern Russia. He lists (*8*) 53 different citations for this species. Some other generic names that have been used in addition to *Corbicula* are *Tellina, Cyrena,* and *Cyclas.*

Uses of Asiatic Clams

Asiatic clams are reportedly used as fish bait in the regions where they occur in Central California. Some specimens now in the US National Museum were taken from the stomach of a sturgeon that was caught in the Columbia River near Bonneville Dam in 1950. In Asia and in the Pacific Islands Asiatic clams are used as food for human consumption. In streams in the vicinity of the municipality of Taipei, Taiwan, as many as 200 fishing boats, mostly on the Tanshui River, may be seen trawling for them (*4*). It has been estimated that over 300 families of the Taipei municipality make their livings in this way. A good day's clam fishing for a one-man boat may result in a catch of about 100 lb. Large and medium-sized clams are sold alive; clam meats are also dried for sale. Small-sized clams are used for feeding ducks. In addition, on the Keelung River in the vicinity of the municipality of Taipei, ducks, themselves, forage for clams.

Data indicate (*4*) that the annual worth of *Corbicula* clams to the Taipei fishery is several million Taiwan dollars. It is not clear (*4*) as to whether *Corbicula fluminea* is the sole species marketed, or whether the estimates are also based on *Corbicula formosana,* which is also found in abundance in the Tanshui River in the vicinity of Taipei, and which apparently prefers brackish water.

Acknowledgments

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References

1. Ingram, W. M. The Larger Fresh-Water Clams of California, Oregon, and Washington. *J. Entomol. and Zool.,* **40**:72 (1948).
2. Clarke, K. B. The Infestation of Water Works by *Dreissensia polymorpha,* a Fresh-Water Mussel. *J. Inst. Water Engrs.,* **6**:370 (1952).
3. Ingram, W. M. Snail and Clam Infestations of Drinking Water Supplies. *Jour. AWWA,* **48**:258 (1956).
4. Yung, D. F. *Report on the Pollution Survey of the Tanshui and Keelung Rivers in the Taipei Municipal Area.* Final Rept. Taiwan Institute of Environmental Sanitation, PHS, 2 Vols. (1958).
5. Drinking Water Standards. *Pub. Health Repts.,* Reprint No. 2697, USPHS, Washington, D.C. (Mar. 15, 1946).
6. Wright, W. H. Private communication.

7. INGRAM, W. M.; COOKE, W. B.; & HAGERTY, L. T. Snails Associated with Sewage Treatment Installations. *Sew. & Ind. Wastes,* **30**:821 (1958).
8. PRASHAD, B. Revision of the Asiatic Species of the Genus *Corbicula,* 3. The Species of the Genus *Corbicula* From China, Southeastern Russia, Tibet, Formosa, and the Philippine Islands. *Memoirs Indian Museum* **9**:49 (1929).
9. VILLADOLID, D. V. & DEL ROSARIO, F. G. Some Studies on the Biology of Tulla (*Corbicula manillensis* Philippi), a Common Food Clam of Laguna de Bay and Its Tributaries. *Philippine Agriculturist,* **19**:355 (1930).
10. DUNDEE, D. S. & DUNDEE, H. A. Extensions of Known Ranges of Four Mollusks. *The Nautilus,* **72**:51 (Oct. 1958).

Water Yield and Reservoir Storage in the United States

In a five-page report, recently published by the US Geological Survey as Circular 409, Walter B. Langbein discusses the amount of water now made available by reservoir storage and considers the prospects for increasing that amount to meet estimated future needs. According to the report, the aggregate capacity of regulatory reservoirs in the United States (exclusive of those of less than 5,000 acre-ft capacity) increased from 33,000,000 acre-ft in 1920 to 273,000,000 acre-ft in 1953, and the trend in construction is still upward. The computed annual water supply made available by present reservoirs is 190,000,000 acre-ft. This amount, reduced by an estimated net evaporation loss of 10,000,000 acre-ft (mostly in the western states), is 13 per cent of the total flow of the nation's rivers.

Water control through storage is governed by the law of diminishing returns; each successive increment of control requires more storage space than the preceding increment. Storage capacity equal to a year's flow can regulate 40 per cent of the flow, but doubling the capacity only increases regulation by about a third. Thus, although a considerable increase in usable supply could be obtained through additional storage in the East, some drainage basins in the western states may already be approaching a limit. In the Colorado River, for example, an increase in the present storage capacity of 29,000,000 acre-ft to a proposed 50,000,000 acre-ft would probably be largely offset by increased evaporation losses.

It has been estimated that an annual increment of 10,000,000 acre-ft of storage will be necessary to meet anticipated increases in water use. At that rate increased demand will approximately double the amount of necessary storage in the next 25–30 years. The biggest challenge offered by the prospect of increasing demand is that of providing storage where it will be most effective. Estimates have shown that proper placement of storage could mean the difference between a necessary capacity of approximately twice the present capacity and more than four times that amount.

Zone of Aeration and Its Relationship to Ground Water Recharge

Irwin Remson, James R. Randolph, and Henry C. Barksdale

A contribution to the Journal by Irwin Remson, Geologist, James R. Randolph, Geologist, and Henry C. Barksdale, Hydr. Engr., all of Ground Water Branch, USGS, Trenton, N.J.

CERTAIN phases of the relationship of the zone of aeration to the water table, climatic factors, and ground water recharge have been studied at Seabrook, N.J. The description in this article of the occurrence of water in the zone of aeration at Seabrook is based largely upon tensiometer readings.

Recharge

Water percolating into relatively dry sediments at Seabrook must wet each layer of the aeration zone approximately to field capacity before moisture drainage to the layer below can take place at a substantial rate. The depth to which a given rainfall or irrigation application, or both, penetrate depends largely upon the thickness and previous moisture content of the top layer of the aeration zone. The rate at which the water penetrates depends upon the amount of water and the nature of the sediments. If insufficient water is applied to the surface to wet the unsaturated zone to field capacity the percolating water stabilizes at some level above the water table and then dissipates by much slower downward drainage and by vapor transfer.

Ground water recharge generally occurs by the infiltration and downward percolation of precipitation or stream flow through the zone of aeration to the water table. Hydrologic conditions in the zone of aeration are critically important in ground water recharge and are not completely understood. This article will describe studies of movement of water in the zone of aeration made by USGS at two especially favorable sites at Seabrook, N.J. One site is in a forest clearing where the water table is approximately 17 ft below the land surface; the other is in an open, grassy area where the water table is approximately 13 ft below the land surface. The sediments at these sites are predominantly sandy.

The description given in this article is applicable for the soil and climatic conditions at Seabrook and should not be assumed to apply elsewhere without further study. However, it is believed that the results of the study confirm Meinzer's threefold division of the zone of aeration (*1, 2*) described later in this article.

Suction and Field Capacity

Suction, or soil-moisture tension, is a measure of the attraction of the soil for water at any given point. Suction generally decreases as the moisture content of the soil increases. As stated

by Baver (*3*): "A moist blotter will soak up less water than a dry one. Part of the attractive forces within the blotter have been satisfied by previous moistening."

Suctions in the unsaturated soils at Seabrook, N.J., are measured by means of tensiometers (Fig. 1). A tensiometer is a water-filled permeable, ceramic

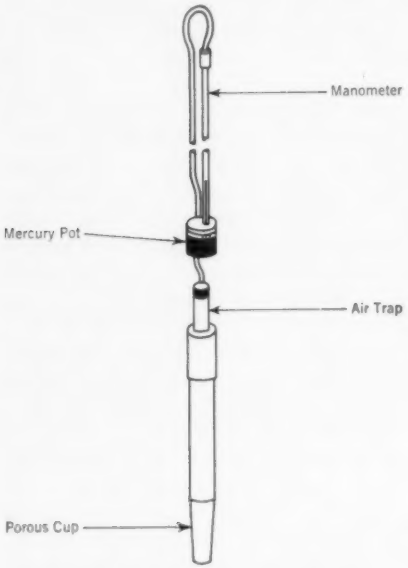

Fig. 1. Soil-Moisture Tensiometer

Suctions in the unsaturated soils at Seabrook, N.J., were measured by tensiometers. The tensiometers indicated suction in terms of centimeters of water.

cup or cell which is connected to a mercury manometer by water-filled tubing. The cup is placed in contact with the soil (Fig. 2) and as the soil dries water leaves the cup and enters the soil. The suction responsible for pulling the water out of the cup is registered by a rise of the mercury in the manometer. As the moisture in the soil increases and the tension of the water in the soil becomes less than that in the cup, water enters the cup again and causes the mercury in the manometer to fall. The tensiometers used at Seabrook indicate the suction in centimeters of water.

Darcy's Law, which describes moisture movement in a porous medium having a liquid continuum, is sufficiently accurate for many practical applications in the wetter ranges of unsaturated flow (*4, 5*). The rate and direction of water movement are determined by the product of the capillary conductivity and the gradient of the combined suction and gravitational potentials. Capillary conductivity in unsaturated flow is analogous to permeability in saturated flow, but with a major difference. In saturated flow permeability is a constant for a given material, fluid, and temperature, but capillary conductivity varies with moisture content because only that part of the pore space with a continuous water film or filament can transmit water as a liquid.

As a soil dries the suction increases and progressively smaller capillary interstices are dewatered of all but the most tightly held water. According to Childs and Collis-George (*6*): "For a given pressure deficiency, a cell will be empty of water if its largest interconnecting channel is too large to accommodate an air-water interface of sufficiently sharp curvature to maintain that pressure deficiency." Dewatered capillary interstices cease to transmit water as a liquid, except by complex and relatively slow processes, and the capillary conductivity of the drying soil decreases. As drying continues the capillary conductivity eventually becomes so small that further moisture distribution must take place through

movement in the vapor phase or through other more complex processes (*3, 7*).

Field capacity, as described by Veihmeyer and Hendrickson (*8*), is: "the amount of water held in the soil after the excess gravitational water has drained away and after the rate of downward movement of water has materially decreased." For practical purposes a well-drained soil is usually considered to be at field capacity 2 or 3 days after a thorough wetting. According to Bodman and Colman (*9*) field capacity is not an equilibrium constant but a narrow range of values at which the drainage rate becomes very small. According to Moore (*7*) it corresponds to the suction range at which the capillary conductivity becomes very small in a draining soil.

Zone of Aeration

The zone of aeration, according to Meinzer (*1, 2*), has three principal divisions:

1. The lowest belt, the capillary fringe, is: "the belt immediately above the water table that contains water drawn up from the zone of saturation by capillary action."
2. The intermediate belt: "lies between the belt of soil water and the capillary fringe."
3. The top belt, the belt of soil water: "consists of soil and other materials that lie near enough to the surface to discharge water into the atmosphere in perceptible quantities by the action of plants or by soil evaporation and convection."

Capillary Fringe

In the open, grassy site at Seabrook tensiometer cups were set approximately 9, 10, 11, 12, and 13 ft below the surface. The depth to the water table increased from about 10½ ft in mid-April to 14 ft in mid-July 1956. In general the tensiometers, acting as piezometers, registered negative suctions (corresponding to positive hydrostatic heads) as long as water tensions in their cups were beneath the water table; they registered positive suctions when their cups were above the water table. The tensiometer readings correlated rather well with the fluctuation of the water table, except for the readings for the 9-ft cup after the early part of May and, to a lesser degree, those for the 10- and 11-ft cups near the end of the period.

The correlation can be explained as follows: in a continuous hydraulic system a gravitational force equivalent to X cm of water tends to dewater any capillary interstices located X cm above the water table. In the absence of percolation from above dewatering continues until the suction increases to X cm of water. The remaining water can then be held against gravity. Therefore, the suction, in centimeters of water, equals the height, in centimeters, above the water table at equilibrium (*10, 11*).

If precipitation and evapotranspiration stop and the water-table position and other hydrologic factors remain constant for an extended period of time all the sediments in a continuous hydraulic system will drain until the tensiometer readings equal the cup heights above the water table. Under the constantly varying field conditions at the Seabrook sites the readings appeared to be equal for a belt of varying thickness directly above the water table. It seems probable that this part of the zone of aeration at Seabrook is equivalent to the capillary fringe.

Rainwater lowers the suctions of unsaturated sediments through which

it percolates. The sandy materials at the 9–13-ft levels at the Seabrook sites have high capillary conductivities when they are within the capillary fringe. Therefore, rainwater drains rapidly until the tensiometer readings and the cup heights above the water table are equal. Where sediments are of low permeability or rates of precipitation and water-table fluctuation are greater, the tensiometer readings and the cup heights above the water table may be unequal even directly above the water table.

In homogeneous, isotropic sediments moisture contents, capillary conductivities, and drainage rates decrease as distance above the water table increases. They appear to become critically small at some level above the water table at Seabrook, and the suctions above this level do not correlate with the water-table position. According to Moore (*7*), field capacity corresponds to the range of suctions at which capillary conductivity becomes critically small. The authors believe that the level above the water table

Fig. 2. Tensiometers at Test Site

Tensiometers were placed in contact with the soil at both of the test sites. These tensiometers are located at the forest clearing where the water table is approximately 17 ft below the land surface.

at which the capillary conductivity becomes critically small—the level at which the material is at field capacity—marks the top of the capillary fringe.

Intermediate Belt

The thickest unsaturated sediments at the Seabrook study sites are above the capillary fringe and below the belt of soil water. This part of the zone of aeration is called the intermediate belt. Moisture contents and suctions in this belt are affected, of course, by water percolating down from the land surface and water coming up from below as the water table rises. However, except for the important periods following penetrating rainfalls, which are discussed later in this article, the rates of response to these processes are usually very low because of low capillary conductivity in this belt.

Moisture contents at any level in the intermediate belt depend upon the percolation rates to and from that level. Changes in moisture-moving gradients are small in the intermediate belt in comparison to changes in capillary conductivity; the rates of drainage and percolation, therefore, depend mainly upon the capillary conductivity. Moisture contents generally are the same or slightly less than field capacity in this belt and capillary conductivities and drainage rates are low. However, after penetrating rainfalls moisture contents may be raised temporarily above field capacity; capillary conductivities and drainage rates are then higher.

Records are available for suctions at the 10-ft level in the intermediate belt under the forest clearing site at Seabrook from the latter part of March through December 1954. During the period before June substantial amounts of rain water occasionally percolated to this level and raised moisture contents to higher than field capacity. Rapid drainage then brought the moisture contents and suctions back to the level of field capacity. The suctions would then tend to rise slowly to higher than the field capacity value by slow drainage at lower capillary conductivities; before they could rise very far, however, they would be lowered by subsequent additions of rain water. Thus, from March through May the suctions in this sandy material fluctuated within a narrow range of values, between 35 and 40 cm of water. This range presumably indicates field capacity at the 10-ft depth under the conditions of depth to water, ground water recharge, and drainage that prevail at the forest clearing site.

Evapotranspiration increases during the warmer months and little rain water percolates to the intermediate belt. Drainage of this belt continued at a low rate during the period of record because of the low capillary conductivities when moisture content was below field capacity. The suctions at the 10-ft level started to rise in June 1954 and reached a level of slightly more than 100 cm of water in November. The slowness of the rise is believed to have been due mainly to the low capillary conductivity and to replacement of a part of the water draining downward by water draining similarly from the overlying materials. Substantial amounts of rain water again percolated to the 10-ft level during December and the suctions returned to the field capacity level.

Ground water recharge occurs at a variable rate in the humid Seabrook area. During summer and early autumn the intermediate belt drains very

slowly because the moisture contents are below field capacity; recharge is less than discharge and the water table declines. During winter and spring the intermediate belt is wetted by percolating rain water and drains rapidly when the moisture content is above the field capacity level; ground water recharge then exceeds discharge and the water table rises.

Soil Water Belt

Moisture contents in the upper part of the zone of aeration at Seabrook depend upon the rates at which water is added by precipitation and removed by drainage and evapotranspiration. Drainage directly affects the underlying unsaturated sediments and rain water occasionally penetrates directly to the water table. Although evapotranspiration indirectly affects the entire unsaturated zone it removes moisture directly only from the uppermost part. The part of the unsaturated zone at the Seabrook sites from which water is discharged directly by evapotranspiration is called the belt of soil water.

The depth to which the belt of soil water extends is approximately equal to the root depth of the vegetation. At Seabrook it is a few inches under unvegetated surfaces, 1 or 2 ft in crop- and grassland, and several feet under forest cover.

When the evapotranspiration rate is low at Seabrook—during cool or cold weather—suctions in the belt of soil water are often lowered below the field capacity level by precipitation but the soils rapidly drain back to field capacity. Thereafter, suctions increase more slowly because of the decreased drainage rates when moisture contents are low and because of the low evapotranspiration rate. During the warmer months evapotranspiration usually exceeds precipitation and suctions often rise above the theoretical limit of tensiometer operation, 1 atmosphere. During prolonged dry periods, according to Richards (*12*), the belt of soil water is sometimes depleted to the permanent wilting percentage, at a suction rate of approximately 15 atmospheres.

For short periods and under the given conditions the lower boundary of the belt of soil water at Seabrook can be approximately delineated. On Jul. 3, 1956, suctions at the ½-, 1-, and 1½-ft levels under the grassy site were, respectively, more than 1,000, 712, and 160 cm of water. The high suctions at the ½- and 1-ft levels were caused by moisture depletion as a result of evapotranspiration. The much lower value at 1½ ft indicated that the roots were removing much less water at that level, and, thus, that the 1½-ft level was near the bottom of the belt of soil moisture. This was confirmed by measurement of the roots.

General Observations

Applied water does not distribute itself uniformly throughout the length of a soil column unless it is in sufficient quantity to bring the entire soil column to field capacity level. Instead, it percolates downward as a nearly saturated belt, leaving little islands of moisture in its wake. Movement of the water stops when enough moisture has been left behind so that the capillary forces equal the gravitational forces (*13*). Expressed differently: the applied water moistens a certain depth to field capacity and then the water movement practically ceases. More water must be applied to obtain further penetration as a liquid (*14*). According to Bodman and Colman

(*9*) the moving water advances behind a "wetting front"—a sharp differential in moisture content.

Enough water must be applied to wet the entire zone of aeration to the field capacity level before substantial ground water recharge can occur. Otherwise, according to Hansen (*15*), the wetting front ceases to move and is stabilized above the water table. Ground water recharge then occurs only by slow drainage when the moisture contents are below field capacity or by vapor transfer. These relations are modified in structured soils and in sediments that develop shrinkage cracks upon drying.

TABLE 1

*Depth of Water Penetration**

Date	Water Application *in.*	Depth of Penetration *ft*
Aug. 1–2, 1955	1.70	4
Aug. 8, 1955	1.57	3
Aug. 11–13, 1955	4.32	to water table
Aug. 18–19, 1955	1.45	6
Sep. 19–20, 1955	2.35	4
Jul. 19, 1956	1.64	2
Jul. 27–28, 1956	4.32	to water table
Sep. 6, 1956	4.55	to water table

* Grassy site at Seabrook, N.J.

Wetting fronts penetrating the zone of aeration at the Seabrook sites have been studied by means of tensiometers. Some reach a given level and stop moving and the water above them gradually dissipates by slow drainage and by vapor transfer. At times two or more wetting fronts from different rainfalls move downward independently of each other. Some wetting fronts penetrate the entire zone of aeration and substantial ground water recharge occurs.

The intermediate belt usually has a moisture content close to field capacity in the humid Seabrook area. Any substantial quantity of water entering this belt wets it to field capacity level and still leaves an excess for rapid ground water recharge. Thus, the amount of water percolating to the intermediate belt from the overlying belt of soil water determines whether substantial ground water recharge occurs. If the belt of soil water is relatively dry because of high evapotranspiration or low rainfall rates substantial rainfall may be required just to wet it to field capacity. Conversely, during periods of small evapotranspiration or large precipitation a small rainfall may moisten the soil belt to field capacity and leave substantial excess water to percolate to the intermediate belt and then to the water table.

Table 1 shows the penetration depths to which differing applications of water were traced during different months of the year at Seabrook. During these particular months—which were a period of high evapotranspiration at Seabrook—water in applications as large as 2.35 in. was used to wet the upper part of the zone of aeration to field capacity. These applications left no excess water for further percolation. Only the three applications that exceeded 4 in. satisfied all soil-moisture deficiencies and recharged the ground water body. These three applications showed why ground water levels decline at Seabrook during the warmer months when evapotranspiration losses are large.

Smaller water applications can result in ground water recharge during periods of low evapotranspiration when soil-moisture deficiencies are small. Rainfalls of 1.48 in. on Apr. 16–17,

1954, and 1.10 in. on Apr. 6–8, 1955, were traced to the capillary fringe at both of the Seabrook sites; ground water recharge occurred after both of these rainfalls. These rainfalls showed why ground water levels rise more readily in response to rainfall during the cooler months when evapotranspiration is low than during the warmer months when it is high.

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References

1. MEINZER, O. E. The Occurrence of Ground Water in the United States, With a Discussion of Principles. *USGS Wtr. Supply Papers,* No. 489 (1923).
2. MEINZER, O. E. Outline of Ground Water Hydrology, With Definitions. *USGS Wtr. Supply Papers,* No. 494 (1923).
3. BAVER, L. D. *Soil Physics.* John Wiley & Sons, Inc., New York (2nd ed., 1948).
4. RICHARDS, L. A. Capillary Conduction of Liquids Through Porous Mediums. *Physics,* **1**:318 (1931).
5. HALL, W. A. An Analytical Derivation of the Darcy Equation. *Trans. Am. Geophys. Union,* **37**:185 (1956).
6. CHILDS, E. C. & COLLIS-GEORGE, N. Soil Geometry and Soil-Water Equilibria. *Discussions Faraday Soc.,* No. 3:78 (1948).
7. MOORE, R. E. Water Conduction From Shallow Water Tables. *Hilgardia,* **12**:383 (1939).
8. VEIHMEYER, F. J. & HENDRICKSON, A. H. The Moisture Equivalent as a Measure of the Field Capacity of Soils. *Soil Sci.,* **32**:181 (1931).
9. BODMAN, G. B. & COLMAN, E. A. Moisture and Energy Conditions During Downward Entry of Water Into Soils. *Soil Sci. Soc. Am., Proc.,* **8**:116 (1944).
10. BUCKINGHAM, E. Studies on the Movement of Soil Moisture. *US Dept. Agr. Bur. Soil Bul.,* No. 38 (1907).
11. DAY, P. R. Soil Moisture Tension Measurement: Theoretical Interpretation and Practical Application. *Proc. 3rd Natl. Conf. on Clay and Clay Minerals,* Houston, Tex., 557. The Rice Inst., Natl. Research Council (1955).
12. RICHARDS, L. A. Retention and Transmission of Water in Soil. *Yearbook Agr. (US Dept. Agr.),* 144 (1955).
13. SMITH, W. O. Private communication (1957).
14. VEIHMEYER, F. J. The Validity of the Assumption That It Is Possible to Produce Different Moisture Percentages in Field Soils. *Trans. Am. Geophys. Union,* **20**:544 (1939).
15. HANSEN, V. E. Infiltration and Soil Water Movement During Irrigation. *Soil Sci.,* **79**:93 (1955).

Distribution Problems in Areas of Unstable Ground

Emil S. Mamrelli

A paper presented on Oct. 30, 1958, at the California Section Meeting, Los Angeles, Calif., by Emil S. Mamrelli, Assist. Engineer of Water Distribution, Dept. of Water and Power, Los Angeles, Calif.

WITHIN a 30-mi radius of the Los Angeles city hall there are more than 100 unstable-ground areas. These are divided into two classes: slide areas and subsidence areas. The earth movement in these areas has caused extensive damage, and, if the earth movement is not stabilized, considerable additional damage will result.

Subsidence

Engineers and geologists have stated that subsidence is the result of the extraction of oil and gas. As the oil and gas are pumped, pressure is relieved and the overlying strata depress. There are two major areas affected: one located in the Baldwin Hills southwest of the Los Angeles business district, and another located in the northwestern portion of Long Beach, extending into Wilmington and San Pedro.

The center of the Baldwin Hills subsidence is located in unimproved Los Angeles County territory. To date there has been only a very small amount of earth movement in the improved city area to the north and east, and, consequently, there has been no appreciable damage.

The center of subsidence in the Long Beach area is located on Terminal Island in the vicinity of Southern California Edison Co. property. The settlement at this location exceeds 24 ft. In Fig. 1 are shown the subsidence contours and the horizontal movements that had taken place as of August 1957. North of the center of subsidence, the horizontal movement of more than 3.5 ft toward the center and, in the west, the horizontal movement of 0.14 ft away from the subsidence center should be noted. Engineers and geologists state that at the present rate of pumping, subsidence will exceed 35 ft before it becomes stabilized. Extensive construction of dikes and levees, raising of flood control channel walls and filling of ground surface have been required to protect the land from being inundated by sea water. In addition to continuing this kind of work, it will be necessary to raise street grades, water mains, gas pipes, sewers, buildings, and railroad tracks.

The water system maintains a distribution system on Terminal Island and on the mainland. A 16-in. main installed in Henry Ford Ave. provides water supply to the eastern portion of Terminal Island. This 16-in. main crosses under the Cerritos Channel in the vicinity of a drawbridge. Vertical settlement at this location exceeds 14 ft and it has been necessary

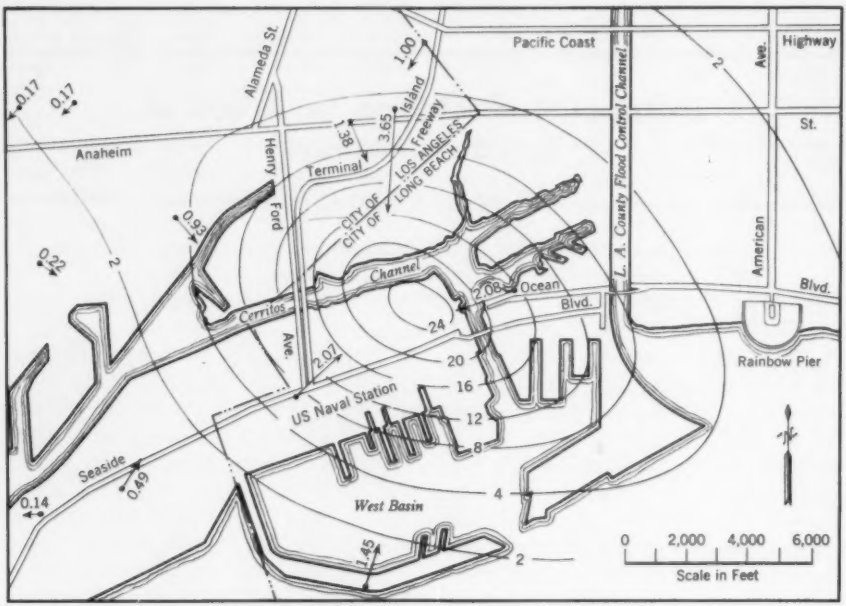

Fig. 1. Subsidence and Slides at Long Beach, Calif.

Subsidence contours are in feet. Arrows indicate horizontal movements that had occurred as of August 1958.

Fig. 2. Pacific Palisades Landslide

Ths slide has covered the highway twice within the last 2 years; the aerial photograph is of the March 1958 slide.

to raise this bridge two times to provide clearance across the channel. The main was installed with flexible couplings, and near the drawbridge approach, long-sleeved, expansion–contraction couplings were used in the horizontal and vertical portions of the pipe to permit flexibility and elongation. No break or leak has occurred at these particular locations. At a short distance north of the Cerritos Channel, however, water service is provided to the Henry Ford Assembly Plant through a 12-in. lateral. In May 1957 a 12-in. gate was broken. In August 1958 the flange on the new gate was sheared, and after excavation for repairs, there was a 6-in. horizontal displacement at this point. In October 1958 water was observed on the surface at approximately the same location. The 16-in. main was immediately shut down and repairs were made without a serious break. It was found that a long-sleeved expansion–contraction coupling had pulled and was leaking.

Engineers and geologists state that subsidence can be retarded and quite possibly stopped by injecting water under pressure into the underground basins as oil and gas are pumped. Two years ago an amendment to the state constitution was placed on the ballot, which would require all oil companies to inject water into underground basins. This amendment was not approved by the electorate. Recently the Richfield Oil Company has indicated that it intends to pump water into the underground basins in which it is operating. It is hoped that other major oil companies will follow this example.

Landslides

There are more than 100 slide areas in the metropolitan area, of which two are of major importance. One is located in the Palos Verdes Hills and the other along the Pacific Coast Highway north of the city of Santa Monica. Many of these slide areas are old geologic formations which have been unstable for many years. In some instances, the unstable condition is the result of excavations and fills for roadways, building sites, or other improvements.

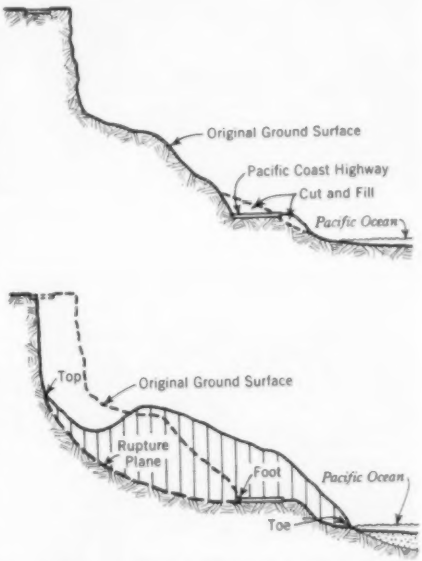

Fig. 3. Earth Movement During Pacific Palisades Slide

The upper and lower cross sections show conditions before and after the slide, respectively (Fig. 2).

The slide along the Pacific Coast Highway has been quite active and within the past 2 years has covered the highway on two different occasions. A view of the March 1958 slide debris is shown in Fig. 2. Figure 3 is a cross section showing this area before and after the slide. The slide plane, or rupture plane, typically occurs with the concave side up. When introduced

Fig. 4. Roadway Affected by Slide

Slides undermined this palisades road, Via de las Olas; this road is at the head of the March 1958 slide, which covered the Pacific Coast Highway.

Fig. 5. Rubber Hose Coupling at Paseo Miramar

In areas where instability would require the installation of conventional flexible couplings in too frequent intervals, rubber hose solved the problem.

into unstable material, water is an excellent lubricant, and sufficient quantities can trigger a slide. During the dry summer periods the movement is very slow and often an area will stabilize, but during the wet, winter periods rain and runoff water accelerate the movement.

Most slide movements are quite slow, the rate of movement varying from a tiny fraction of an inch per week to a half-inch per day. The slide affecting the Pacific Coast Highway in the vicinity of Via de las Olas was an exception. Thousands of cubic yards were displaced in a few moments at this location. The material which covered the Pacific Coast Highway 2 years ago was removed and the roadway opened to traffic. After the slide that occurred in March 1958, the state highway department began work of removing the debris from the roadway area. A secondary slide covered construction equipment and an oil truck and killed a workman. After this incident, the highway department stopped the work of removing material at the toe of the slide and new routes were investigated for the relocation of the Pacific Coast Highway. The highway department determined the most economical way to relocate the roadway would be to construct a fill along the beach area. Riprap construction is utilized in the center lane of the new roadway and on the seaward side to protect the compacted roadway fill. Via de las Olas is located at the head of this slide. Before the slides occurred the cliffs were 40–50 ft west of the roadway. Slides undermined portion of Via de las Olas, and this street was closed to traffic. It is expected that the slide will stabilize 150–200 ft back from the present head of this slide (Fig. 4).

Fig. 6. Expansion–Contraction Coupling Between Stable and Unstable Ground

This coupling is at Paseo Miramar. Similar couplings are used in many unstable areas.

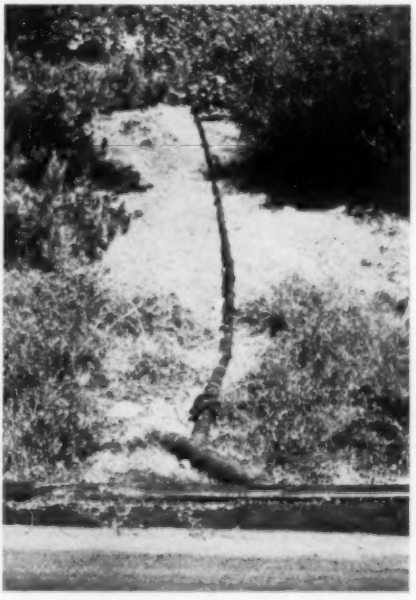

Fig. 7. Temporary Sewer Above Ground

This sewer installation is located at Paseo Miramar.

Fig. 8. Unstable Coastal Area at Palos Verdes

At this location millions of cubic yards of earth are moving slowly towards the ocean. More than 100 homes will eventually have to be evacuated if the ground is not stabilized.

Fig. 9. Buckling of Portuguese Bend Pier

The buckling was caused by the slide of unstable ground toward the water. Portuguese Bend Club facilities at this location have been abandoned.

Distribution Problems

The water utility maintained normal distribution in the unstable Via de las Olas area. Approximately 2 years ago, 2-in. copper tubing was installed just back of the curb or sidewalk with approximately 2–3 in. of cover. Service connections were made with high-pressure rubber hose, bent to permit horizontal or vertical movement. Gate valves were installed just back of the unstable area so that they could be readily closed in the event of a leak or a break in the 2-in. tubing. The 2-in. tubing is strong and flexible and should not break on account of slight earth movements or small slides. If a major slide occurs and breaks the tubing, relatively small quantities of water will be discharged into the slide area before the gates are closed.

A relatively small slide area along the Pacific Coast just north of Sunset Boulevard affects four streets and has been responsible for the demolition of four homes. The slide extends from the highway to a ridge and has required the water system to abandon its water mains in four streets. To maintain service in this area, pipe was installed between streets in easements parallel to the slide. At the head of the slide one roadway (Tramonto Drive) a main was installed back of the curb with 6 in. of cover. Flexible joints and long-sleeved couplings were installed in the pipe to permit horizontal or vertical movement. In the unstable area it is necessary to maintain service to three homes. Coiled copper tubing was placed inside of 12-in. steel pipe to protect the tubing.

During March–April 1958, earth movement on another road (Paseo Miramar) was ½ in. per day. A steel water main was bent about 60 deg between the stable and unstable ground, causing a leak. Long-sleeved type couplings were installed in this pipeline between the stable and unstable portions and it was necessary to maintain daily inspection because of the rate of ground movement in the area. It became necessary to install additional couplings at short intervals, and to solve this problem 6-in. high-pressure rubber hose was installed in the pipeline between the stable and moving ground (Fig. 5, 6). This would have solved the problem for a considerable period; however, it was necessary to maintain a large hole, which was unsightly and dangerous to traffic and trapped runoff water during the rains, adding to the saturation of the unstable material. A permanent solution was the installation of approximately 4,500 ft of main, bypassing the un-

Fig. 10. Rubber Hose Connection on Palisades Highway

This connection, installed above ground to insure fire protection and domestic supply to those still residing in the area, was necessitated by the great instability of the region. The highway is buckling and moving.

Fig. 11. Swivel Joint on Pepper Tree Road, Palos Verdes

This joint allows the pipe to shift with horizontal ground movement.

Fig. 13. Coiled Copper Tubing Used for Service Connection

This is another safeguard against broken service lines owing to ground movement.

Fig. 12. Water and Gas Service Connection on Kumquat Lane, Palos Verdes

Swivel joints are commonly used in this area for aboveground services.

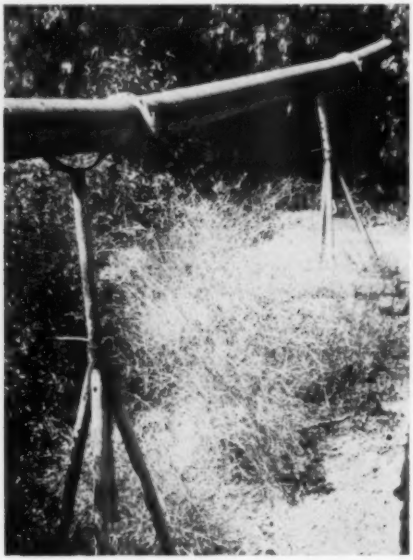

Fig. 14. Tripod Supports for Pipe Across Settlement Area

As the ground settles, the tripods may be adjusted to keep the pipe at a proper level.

stable area. The sewer department also has problems in this area, which can be seen from the temporary surface installations in Fig. 7.

On Mulholland Drive, a short distance east of Sepulveda Boulevard, the water department maintains a 16-in. supply main. This area showed slight movement and the department was quite concerned about the consequences of a break or leak in this pipe. To safeguard the main, a temporary pipe with flexible couplings was installed aboveground outside of the roadway area. Two homes were isolated by a slide in front of their property near this location. Service lines were in danger of breaking, and to maintain service to these homes, a $2\frac{1}{2}$-in. fire hose was laid aboveground, bypassing the unstable area. It was necessary for the sewer department to install rubber hose in the sewer laterals, as the vitrified pipe was badly fractured.

The largest and most damaging slide area in this region is located in the Palos Verdes Hills in the vicinity of Portuguese Bend. The toe of the slide is approximately 1 mi wide along the ocean frontage and extends to a depth of nearly 1 mi north of the beach (see Fig. 8 and 9). The slide plane is located along the beach just above the water line and extends to an elevation of approximately 250 ft near the head of the slide. Millions of cubic yards of earth are moving towards the ocean at a very slow rate, particularly during the summer, and accelerate during the winter rainy season. More than 100 homes will eventually be demolished if this area is not stabilized. A few homes have been demolished by the slide, others have been moved, and the Portuguese Bend Club facilities have been abandoned. The highway on the Pacific Palisades is buckling and moving and the Palos Verdes water company has used a number of ingenious methods to maintain domestic and fire protection service to this area. Thousands of feet of steel pipe with flexible joints and high-pressure rubber hose have been installed above ground (Fig. 10 and 11). Swing joints have been used for distribution mains and for service lines (Fig. 12). Coiled copper tubing has been utilized also (Fig. 13), and at one location, near the head of the slide where the earth has settled primarily vertically, steel pipe is supported above the ground with a tripod and movable extension (Fig. 14). As the ground settles, the extension is raised to retain the pipe at a proper level. Damage in this area alone will run into millions of dollars.

Conclusion

Officials and engineers of the city and county of Los Angeles and California are quite concerned with the damage that can result from unstable ground. The US Coast and Geodetic Survey Department has delegated a geologist to study and prepare a report of the slides that are occurring in this area. It is hoped that an economical method will be found in the very near future to stabilize the areas that are causing extensive damage to public and private property.

Ceramic Sponges for Radioactive-Waste Disposal

C. W. Christenson

From a paper presented on Sep. 17, 1958, at the Rocky Mountain Section Meeting, Denver, Colo., by C. W. Christenson, Group Leader H-7, Health Div., Los Alamos Scientific Lab., Los Alamos, N.M.

It was suggested by representatives of Coors Porcelain Co., Golden, Colo., in March 1958 that liquid radioactive wastes might be soaked up in ceramic sponges, dried, and fired, thus permanently fixing the radionuclides in the ceramic. A similar, independent investigation was reported by Robinson (ORNL-CF-58-4-74, Oak Ridge National Lab., Oak Ridge, Tenn., Apr. 6, 1958).

The process involves the preparation of a highly porous clay body, which is fired to about 800°C. This body is then soaked in the liquid waste, dried, and resoaked. The cycle is repeated as many as five times. The clay body is finally fired at 1,300°C to fix the radionuclide permanently.

The voids in the sponges may be made by using many substances, including burnout materials such as naphthalene, wood, cork, or other organic materials. Gas bubbles and foaming agents may be used, or highly absorptive materials such as calcined clays and diatomaceous earth. The initial, or bisque, firing temperatures and cycles are major factors in the production of maximum porosity. The best pore sizes for effective absorption are yet to be determined. The final product must be strong and dust-free.

In preliminary work at Los Alamos, N.M., it has been found that some of the ceramics will absorb a waste to about 50 per cent of their weight. The amount absorbed by the sponge is essentially the same for each of the first four soaking and drying cycles. After four cycles, subsequent cycles absorb considerably less waste. In several determinations, a sponge has absorbed up to 200 per cent of its weight in waste in four cycles. Additional cycles increase this percentage, but at a slower rate. In some tests, simulated wastes were contaminated with Sr^{90} and Cs^{137}, absorbed in ceramic sponges, and fired to 1,300°C. Subsequent leaching with tap water or distilled water revealed no appreciable radioactivity in the lixivium.

Although cost estimates cannot yet be made, the cost will probably not exceed that of tank storage of liquid wastes. Storage in a solid form is surely a much less hazardous way to contain radioactive wastes. It appears that radionuclides can be very firmly fixed in the ceramic and that no great care need be taken in storage other than providing shielding.

Another advantage of the ceramic-sponge method of disposal is that the sponges can be made in almost any shape, which may make it possible to utilize the gamma and beta rays. It may also be possible to use the heat of decay or radiation for sterilization of foods. Unfortunately, the volume occupied by the sponge radionuclides is somewhat larger than the volume of the original waste, and highly concentrated sources will not be possible.

The ceramic-sponge method of disposal of radioactive wastes has shown considerable promise, and a full-scale investigation is planned. One of the major problems will be the treatment of gases liberated during the drying and final firing of the ceramics.

Problem of Unaccounted-for Water

Jess L. Haley

A paper presented on Oct. 1, 1958, at the Alabama-Mississippi Section Meeting, Biloxi, Miss., by Jess L. Haley, Supt., Water & Light Dept., Clarksdale, Miss.

THERE are only two ways of handling the problem of unaccounted-for water. The first is to ignore it completely by not metering either pumpage or customers and accepting the view that if no attention is paid to the problem it will go away or solve itself. Experience has shown that eventually the problem had to be tackled, however, and that those who tackle it are generally shocked at its extent. The second way to handle the problem is to admit that it should be met and solved. Those who subscribe to this view have found that the problem doesn't stay solved, however. It requires constant attention, or it will become a tremendous financial burden to the water system.

The author still has vivid memories of going from one extreme to the other in handling the problem of unaccounted-for water. In 1949, Clarksdale, Miss., did not have a meter on any of its three wells and had only partially metered services. There was no program for checking, repairing, or testing meters, and the best available estimate up to that time was that the losses ranged from 35 to 50 per cent. The Mississippi Rating Bureau had warned city authorities that more than 50,000 gal of overhead storage was absolutely necessary for Clarksdale's 16,000 people, and that the pressure should be increased from 40 to 65 psi, or a change in classification would be forthcoming. This would have increased fire insurance rates to all people in the city.

The first step to be taken was the approval of a bond issue, which, among other things, provided for two 250,000-gal overhead tanks to maintain system pressure at 65 psi. One can imagine what the increase in line pressure did to the lead joints in the system. It was necessary to uncover almost every one of them, recalking and putting on clamps to prevent more leakage in the future. A large percentage of the leaks caused by the increased pressure showed up on the surface and demanded prompt attention. It is difficult to recall how many clamps were used or leaks repaired in that first year of operation under the new pressure.

Fortunately, in 1950 operation of the water (and electric) systems was placed under the jurisdiction of a non-political board of the public utilities commission, who insisted that the situation be corrected promptly. It isn't often that one has a board that insists that things be done properly and gives the necessary authority to get them done as soon as possible.

Problem

"Unaccounted for" is an excellent phrase. It describes the money that inexplicably disappears from pockets,

the mileage added to a car by teenage offspring, or almost anything that cannot be specifically remembered. In the water supply industry, it is a fairly simple term. Unaccounted-for water is that water that was pumped into the system but did not run through anyone's meter, or was not registered accurately, and could therefore not be accounted for. It is really a problem in simple arithmetic. For any given period—a day, a month, or a year—it reads like this:

Water pumped into the system	1,000,000 gal
Water billed to the customers	700,000 gal
Unaccounted-for water	300,000 gal

This means that for every 7 gal that registered on a customer's meter, 3 gal disappeared, and anyone can tell that it costs just as much to pump the 3 gal for which there is no revenue as it does for any 3 gal that is registered on a customer's meter.

Not only is operating expense increased by the cost of pumping the additional water, but it also means that there has to be more capacity available to supply the biggest customer, "Mr. Unaccounted-for." Some people prefer to call this "loss," which amounts to the same thing. In an average system in good condition, the total loss should not exceed 15 per cent of the water pumped into the system. This is a general statement, and actual experiences vary considerably. In Clarksdale, for example, losses now range in the neighborhood of 10 per cent. This low percentage may be the result, in part, of some very accurate estimates of those uses that cannot possibly be metered, such as street sprinkling and fire extinguishing.

Solution

The only way that a check can be kept on unaccounted-for water is to account for as much of it as possible by maintaining:

1. Accurate metering of water pumped into the system
2. Metering of each and every customer, even the free ones
3. A good program of meter maintenance that will insure the accuracy of all customers' meters and system input meters
4. Good records
5. A common-sense approach in interpreting the records.

If these things are consistently done, a reasonably accurate picture can be formed. It is important that the picture be complete at all times, because losses can get out of hand quickly.

There is one more important item that should be added to the list; it is perhaps the most important item. There must be a real desire to correct the problem on the part of the management and the governing authorities; otherwise, nothing can be done at all. In order to solve the problem, money may have to be spent in sizable quantities, but the dividends on the investment are so great that there can be no doubt that the expenditure is justified. The dividends are twofold: [1] every customer pays his proper share of the cost of operating and maintaining the water system, and [2] the least possible amount of water is put into the system to meet consumer demands.

Master Meters

Only when the amount of water pumped into the system is known can one form any idea of how much should

appear on the customers' meters. Obviously, then, the first step is to meter the wells or the treatment plants delivering water to the system, so that an accurate account of delivery can be obtained. There are many types of meters available and each system has its own preferences and needs. This much can be said with absolute certainty, however: when an investigation is made as to the best meter for a given application, accuracy and simplicity should be sought. It is impractical for a small system to use a complicated meter that nobody understands. The meter selected should be one that somebody in the utility can look after. The determinations of water losses can be no more accurate than the meter that records them.

It should be pointed out that only if all meters could be read in a day would it be possible to get an accurate idea of losses from a single month's reading. For example, if a master meter is read on the last day of the month and customers' meters are read over a period of a week, it is obvious that there is no direct relation between the readings. This is particularly true during the summer months when lawn sprinkling and other factors cause wide fluctuations in usage. Rain influences these and other requirements, and the only way to get an accurate, continuing picture of the losses for unaccounted-for water is through a yearly record.

Customers' Meters

Once it can be determined how much water is going into the system, it becomes necessary to make certain that all customers are accurately metered. Because it usually costs a minimum of $30 per customer to install a meter, a considerable amount of money may be necessary to do the job. This step is probably the one that pays the quickest dividends, however, because a customer quickly reduces his usage when he knows he has to pay for water on the basis of what he uses. This immediately results in reduced pumping requirements. It is inherent in human nature to waste what is plentiful and cheap, and this is perhaps more true of water than of any other commodity.

The installation of meters, or any program that is intended to enforce payment, whether reasonable or not, is likely to bring objections from the public. This makes advance planning and public relations work necessary. Advance publicity, digging up all the answers that will be needed ahead of time, acquainting personnel with these answers, and absolute certainty of the backing of the authorities are important items.

It may be necessary to make a house-to-house survey to determine which dwellings have water service and through what meter it comes. This is not quite as simple as it may seem, particularly in a system that has been so poorly handled that a program of this kind becomes necessary. It may be found that several houses are on one meter, that a meter is located on one street and services a house on another street, that a meter has been installed and forgotten, or that lines run under one house to get to another. Absolute diligence and determination are very important. No apartment, house, dwelling, or building of any kind should escape this survey.

Meter Reading

Once it has been established that all customers are metered, the next re-

quirement is that the meters are read and the customers billed on schedule. It is surprisingly easy to lose track of a meter that has been cut off for any reason. The Clarksdale system requires that every meter be read once a month, whether there is a customer in the house or not. This prevents not only the use of water without the utility's knowledge, but it also makes certain that the meter is not forgotten.

There have also been some meter readers who have decided they could turn in readings without actually seeing the meter when the customer's habits conformed to a pattern. There again Clarksdale meter readers are constantly reminded that turning in a reading that they have not actually made is a ground for immediate dismissal. No estimation of bills is allowed anywhere but in the office where the bills are calculated. The system of meter reading also provides adequate supervision so that a man has to walk a certain distance through a meter route, which comprises the greater portion of the work, and therefore has little to gain by not reading the meters.

Once the meters are read, bills should be calculated accurately and rendered promptly. A followup accounting should be made to make sure that bills are paid; otherwise, the whole system can develop faults. If a customer is somehow overlooked and does not receive a bill, he has no incentive to keep his bill down by using no more water than he actually needs.

Meter Maintenance

It is absolutely essential that meters continue to be accurate. A water meter will practically never overregister. What does happen to its accuracy is that it gets slower as time goes on. Wear on the disc allows water to get past without turning the register. Solid matter in the water collects on the disc, increasing the friction of the disc, and this accomplishes the same result of reduced registration.

If the system can possibly justify it, maintenance, testing, and changing of the meter should be handled by personnel responsible to the manager. The only real initial investment for such a process is test equipment. The additional costs are the salary of the man who does the testing and the cost of repair parts. An alternative method is to have a regular meter-checking program and have the meter repair work done by an outside source. This, however, has a disadvantage in that the people making the test are not immediately concerned with the results of faulty meters and therefore do not have the same interest as someone on the payroll of the system. Also, it is very easy for a water meter to lose some accuracy during shipment, particularly when it is shipped for any long distance and is subject to changing temperatures.

Coding of Meters

Just recently Clarksdale has developed a coding system for meters. The system makes possible the use of very simple numbers and simplifies the identification of a meter.

A young lady was employed on a part-time basis to go through the meter books and make out a history card for each water meter. She supplied the code and then added the company number or manufacturer's serial number, whichever was listed on the meter sheet.

Then the cards were filed, first by the code and then numerically by serial number. As meters come into the shop, they are given a new company number which reduces the number of digits. Although the manufacturers' serial numbers are in the millions, the company numbers will always be four digits, as there are only about 5,000 meters on the system.

In the meter history file, the coding automatically groups all meters by size and manufacturer, so that one may easily determine how many meters there are of a given size or manufacturer. Also, it is no longer necessary to fill in the manufacturer or size on the meter sheet, as the code provides this information in two letters.

It is expected that the meters will soon be commonly known as AB's or CN's to company personnel, which will simplify their handling to some extent. If it is necessary to trace a meter by serial number, one need only look at it, determine the size and manufacturer, and look up the code under which the meter card is filed.

Leak Survey

Not many systems are equipped to make an adequate leak survey, and it is therefore recommended that the leak survey be made by some outside source that does this as its business and is therefore much better equipped and qualified. The opinions and advice of such a source are probably of much greater value than those of personnel who see the system every day.

Money for leak surveys is well spent; they are an absolute necessity for a complete solution to the problem of unaccounted-for water. They provide the only means of detecting the greater part of the leaks. A leak survey is also a very educational experience for the average water utility operator. In following its course, he learns a great deal about his system. A competent survey will locate any water lines that have been lost, because one must have access to all the valves and distributor legs of the system before a leak survey can be accomplished.

Several years ago, Clarksdale engaged an outside group for a leak survey, at a cost of approximately $3,200. For this fee it was possible to locate and list innumerable leaks that did not show on the surface and locate some lines, valves, and meters that had long been forgotten. There was one 2-in. meter that had been lost since its installation approximately 6 years prior to the survey. After the meter had been read, a letter was written to the company involved informing them of the situation. They were kind enough to pay a back bill for $3,500 without any argument.

Records and Analysis

The only meaningful way Clarksdale has found to keep pumping and sales records for determining losses is on a 12-month ending basis. This means, for example, that for the 12-month period ending on Jul. 31, 1958, 686.8 mil gal had been pumped, whereas 624.6 mil gal had been sold, giving a loss of 62.2 mil gal, or 9 per cent. This method of analysis avoids the inaccuracies caused by seasonal variations and discrepancies between the time of reading the customers' meters and the master meter. On the other hand, it has the disadvantage of looking at a year in retrospect. A sudden change in the last month might not be noticed as promptly as it should be. This can be compensated for by examining the

pumping and sales for each month and comparing them to the same month of the previous year. Sudden changes should be noted and any explanations determined. One reason might be an extremely dry month compared to a wet month in the previous year. The 12-month ending data, when plotted on a graph, also provide a clear picture of the growth trend.

Conclusion

Looking back over experiences at Clarksdale, the author has no doubt that the results of the attempt to account for losses and to reduce unaccounted-for water were well worth the cost. The leak survey paid for itself, distribution maps were brought up to date, all of the meters and valves were located, and a modestly good record for controlling the unaccounted-for water was made possible. Personnel are intensely aware of the problem, and when the pumping for a given day seems to them to be higher than normal, they will bring it to the attention of the distribution department, so that leaks are caught before they become more serious.

Types and Uses of Water Storage

Bruno J. Hartman

A paper presented on Sep. 18, 1958, at the Wisconsin Section Meeting, Wausau, Wis., by Bruno J. Hartman, Pres., Jerry Donohue Eng. Co., Sheboygan, Wis.

STORAGE of water for use at some future time is not a modern development or practice. The histories of early civilization make frequent reference to storage of water for human consumption, washing of streets to remove human waste, and irrigation. Works for irrigation in Egypt and India were established on a very large scale, one in Egypt occupying some 30,000 acres. The English, at the time of the early occupation of India, found some 50,000 irrigation reservoirs that had required the construction of some 30,000 mi of earth embankment.

Although the basic concept of storage has not changed materially, modern requirements have by necessity dictated the functions and methods. This article will consider the storage of water as it applies to a modern water system and not to irrigation, flood control, or the development of power.

A water system consists of three separate parts that must be coordinated so as to make a workable system. These are: [1] the source of supply and works for the collection and storage of water, [2] production and treatment facilities, and [3] the distribution system for conveying the water.

Purpose of Storage

In almost every water system, some form of storage is a necessity as well as a convenience. The type and capacity of the storage may vary greatly, but, in general, the purpose of storage is to give flexibility to the distribution system and to enable the different portions to operate somewhat independently of one another.

Independence of operation is desirable from the standpoint of economy and safety and may be of importance in maintaining the quality of the water. If water is carried from the source through a long pipeline or conduit to the point of distribution, a distributing or equalizing reservoir will make it possible to operate the supply line at a uniform rate using minimum pipe sizes because the supply line does not have to supply demand rates. Frequently a reservoir will make it possible to reduce the capacity of pumps, filters, and similar works and to operate them at a uniform rate. This usually results in more economical operation. In a large distribution system, reservoirs at proper locations will reduce the size of pipe necessary and consequently reduce construction costs. Storage may be considered insurance against interruptions of service caused by accidents to pipelines or machinery. It is a safeguard that is more economical than duplication of pipelines and pumping equipment.

When the supply comes from a large stream or natural lake, storage to insure continuity of supply becomes less

important than when the supply is from wells or from a small stream with a fluctuating flow. For this discussion it will be assumed that storage is necessary to maintain continuity of service and for economical operation.

If a water system is without a storage reserve in a form that can provide the system with adequate water at the proper pressure, it is necessary to provide more pumping and distribution facilities. In any water system, the withdrawal of water varies greatly, and without some form of elevated storage it is necessary to have pumping equipment of varied capacities in order to carry fluctuating loads. This can be accomplished by several pumps of different capacities or variable-speed pumps whose operation is controlled by main pressure. The latter method usually requires large expenditures for mains and pumping equipment and results in an uneconomical pumping system, because the pumps do not operate at their greatest efficiency for the larger part of the time.

Benefits of Storage

The introduction of storage of proper volume, location, and elevation makes it possible to reduce the number and capacities of pumps, to operate them at the most efficient rate, and to reduce the size of the distributing mains. This reduces construction costs, fixed charges, and operating costs and provides more satisfactory service. The savings in these costs usually more than offset the cost of storage.

If a well supply is used, ground storage is usually desirable, and its cost can be justified. A reservoir can be filled at night by using off-peak power. Pumping at uniform rates equal to the average 24-hr consumption results in the most economical use of power. Pumping from ground storage to elevated storage during the night is likewise most economical.

Fire Protection

Storage, both elevated and ground, is important in fire protection because it reduces the pumping capacities required by insurance underwriters. These requirements are important because they have a direct bearing on the fire insurance rate in the community. For example, if the underwriters require a withdrawal rate from the hydrants of 1,800 gpm for a period of 6 hr in addition to the regular consumption during that period, if this is equal to a total requirement for the 6-hr period of 700,000 gal, and if the supply is from wells, the capacity of the wells and pumping equipment must be sufficient to deliver 700,000 gal in 6 hr, or 1,950 gpm. In such a community the average consumption rate probably would not exceed 150 gpm; therefore, without any storage, the wells and pumping equipment would have to be capable of delivering 1,800 gpm for fire protection only. Pumping at that rate would be rather infrequent throughout a year, but it would represent a considerable material investment and operating expense.

If this same community had 100,000 gal in elevated storage, 500,000 gal in ground storage, a well with a dependable supply of 600 gpm and two 600-gpm booster pumps, during the 6-hr period the well supply would be equal to 216,000 gal, leaving 484,000 gal to be supplied from elevated and ground storage. Under these conditions, at the end of 6 hr, neither the elevated storage nor the ground storage would be depleted, and there would be a good

supply for fire protection. The deep well pump and booster pumps would be sufficient to pump the normal requirement and a booster would be available for standby service. As a protection against a possible breakdown in the deep well turbine pump, however, this community should also have a fully equipped well for standby service.

In a community that obtains its water from a river, lake, or wells requiring treatment, sufficient storage must be provided for variable consumption rates and for fire protection.

It is good practice to design a treatment plant according to the daily maximum consumption at some future date and provide enough storage that the treatment plant can be operated at a uniform rate during a 24-hr period and the maximum momentary rates can be supplied from storage. It is also important to provide enough storage so that the treatment facilities can produce the requirements in a single 8-hr operating period during the first 35–45 per cent of the design period. The volume of storage is determined by the consumption, methods of operation, local requirements, and construction costs.

Special Demands

In some communities there is a wide variation in loads; the consumption may be very high for a few months, and very much lower for the balance of the year. By a careful study of the water consumption during a special-demand period, it is usually possible to provide enough storage to handle peak requirements for several days at a much lower cost than could be provided by additional wells and treatment facilities.

Storage can be in the form of a reservoir, elevated storage in a standpipe, or an elevated storage tank supported on a structural-steel or concrete framework. Local conditions dictate the form to be used. In many communities both elevated and ground storage are used.

Ground Storage

Ground storage reservoirs, as a rule, serve as an equalizing basin between the source of supply and the distribution system. They permit the wells or treatment plant to be operated at economical, uniform rates rather than at rates that vary to meet variations in demand. The capacity of a reservoir is usually governed by considerations of location, safety, economy, and special requirements rather than by a rigid rule or formula. In determinations of the proper capacity, the cost of a reservoir should be balanced against the benefits in safety, reduced expenses of other structures, and reduced operating costs. This question can be solved by providing any one of three degrees of reliability: [1] the capacity necessary to equalize the demand for a single day only; [2] a greater capacity than this to provide more economy and safety; or [3] a capacity less than this where the cost of a reservoir cannot be justified.

Elevated Storage

It is the usual practice to provide storage at an elevation that will develop a satisfactory pressure throughout the distribution system. This gives more economical operation and service than maintaining system pressures by pump operation. The water can be pumped from ground storage to elevated storage at a uniform rate,

and the elevated storage then can act as an equalizing tank between the pump and demand rates.

Elevated storage usually is more expensive than ground storage when the cost is based on 1,000 gal. Therefore, a minimum volume is usually provided. In small communities, elevated storage is provided for the economical operation of pumping equipment, usually 25–40 per cent of the average daily consumption. In large cities, elevated storage is provided to meet sudden demands and fluctuating loads in particular areas. The capacity of elevated storage ordinarily will range from 0.5 to 2 mil gal per tank. Where a larger volume is required, it is obtained through the use of more than one tank.

The location of elevated storage may be governed by topography, in which case the alternatives may be limited and poor. Usually it is poor practice to place elevated storage at a high elevation simply to save tower height, thus disregarding its true function. Although construction costs may thereby be saved, the additional cost of pipelines and pumping equipment may more than offset any saving. A long, single pipeline may be exposed to hazards that could interrupt service. In general, elevated storage should be located as centrally as possible on the distribution system it is to serve, because this insures the most uniform and satisfactory pressure and requires the smallest number of mains and branch mains. When consumption exceeds the pumping rates, the system can get its additional requirements from elevated storage, and when the pumping rates exceed the consumption, the surplus flows to storage.

Conclusion

Water storage facilities, either ground or elevated, their capacities, and their locations play an important role in the economical and efficient operation of any water system. There is no rigid rule that applies to all communities. Each community has its own problem, which can only be solved by a careful study of the topography, source of supply, and local requirements.

Rain Catchment Basins in the Caribbean

Ramon M. Guzman

A contribution to the Journal by Ramon M. Guzman, San. Engr., Caribbean Area Public Works Office, US Navy, Rio Piedras, Puerto Rico.

THE technology of modern warfare has made necessary the development of shore establishments at small isolated coral islands in both the Atlantic and Pacific oceans. This article refers to one of the many problems encountered at this type of shore facility: potable water supply.

Problems similar to those discussed in this article probably are encountered at many other similar facilities or on small islands where the construction of rain catchment areas is required due to the lack of adequate surface or deep well water. This may be complicated by the fact that the catchment basins have to be constructed near the shoreline because of limited surface area.

The US Navy has constructed a number of these facilities. Rain water is collected in a catchment basin and is pumped to the raw-water storage tanks, from which it passes to a small filtration plant. The water is filtered through diatomaceous-earth filters and disinfected with hypochlorite. The treated water is finally pumped through the distribution system and to the fresh-water tanks. There are standby distillation units for the distillation of sea water during periods of prolonged drought or when the water in storage is in short supply. These periods are frequent. Figure 1 is a typical flow diagram for the small potable water systems at these facilities.

In November 1955 the author was called upon to investigate the nature of an amber color and a noticeable mineral taste in the potable water on one of the Bahamas. Both the color and the mineral taste were unusual because rain water is free from these impurities.

Petroleum Asphalts and Color

This rain catchment basin is constructed on a sandy soil and is covered with coral and an asphaltic-seal coat to reduce the loss of water through percolation. The problems start as soon as rainfall hits the catchment basin. The rain water, once on the catchment basin, is discolored by the dissolved organic asphaltic substances, which produce an amber color. The pickup of asphaltic constituents has produced a color in the water as high as 100 units (platinum–cobalt scale). This is highly in excess of the maximum limit of 20 units recommended by USPHS (*1*).

Petroleum asphalts consist of a nonmineral matrix composed mainly of saturated and unsaturated hydrocarbons, polymers, insoluble matter, and associated mineral constituents, such as calcium and magnesium carbonates and silicates. The content of mineral matter varies from 0.1 to 0.8 per cent. Natural asphalts may contain a much larger amount of mineral mat-

ter, with values ranging from 0.2 to 30 per cent, but the nonmineral matrix has the same constituents as that of petroleum asphalts. The dark color of all asphalts is caused by the liberation of colloidal carbon under the influence of heat; the colloidal carbon is adsorbed by the hydrocarbons once it is formed (*2*).

The asphaltic materials that produce discoloration of the water are probably hydrocarbons. Although the exact nature of the substances present in the water under investigation was not known, there are some asphaltic substances might in the long run cause adverse physiological conditions in the body. It may be that in the future the tour of duty at these facilities will be extended beyond its present 1-year maximum, and the cumulative effect of the asphaltic substances will be given greater consideration. There was therefore a special reason, besides complying with USPHS standards, for removing this color. In the laboratory, although it was possible to dissolve these substances in a wide variety of organic solvents, the selective tests by spectrophotometric examination failed to identify them because the amounts present were too minute. When samples were evaporated the water left a black and white residue. Evidently, the white residue corresponds to the inorganic mineral matter present in the water, and the black residue accounts for the color picked up from the asphaltic cover in the catchment basin. All the residue was readily dissolved when the evaporated water was replaced.

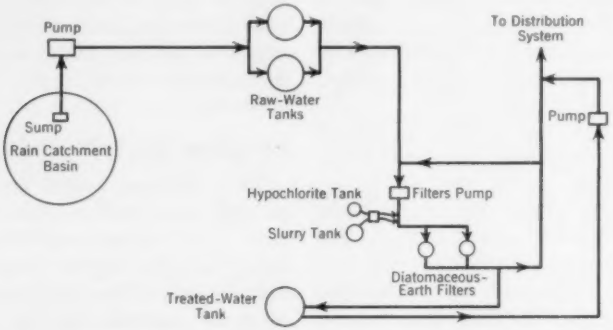

Fig. 1. Flow Diagram of Typical Rain Catchment Installation

A number of facilities of this kind are being used by naval installations on small coral islands. In addition to the catchment installation, standby distillation equipment is provided for converting sea water during periods of drought, which are frequent.

Removal of Asphaltic Constituents

Methods for removing or reducing the asphaltic constituents from the water were carefully evaluated. It is possible that the molecules producing the color were complex hydrocarbons of such large structure and high molecular weights that they acted as organic colloids. In fact, the paving of

the catchment area by the hot asphalt mix is itself the gelatinization of colloids and the cake that covers the area is formed by the gradual cooling of a heated sol.

The greater the structure of the hydrocarbon molecule in asphalt, the less soluble it is. Reduction of the electrokinetic forces of the colloids present in the water may be performed by chemical methods, which would probably be easy in this type of water because of its saline condition. This would, however, require additional equipment at the small filtration plant. A simpler method would be adsorption of the colloidal particles by the application of a slurry of activated carbon. The great surface area exposed by the activated carbon would be a real asset in adsorbing the constituents that produce discoloration of the water. Experiments conducted at the laboratory indicated that it was possible to adsorb these complex constituents by the application of activated carbon. At operational scale the activated carbon was mixed with diatomaceous earth slurry, because the application of activated carbon at this point had been successfully used at other military installations (*3*).

The gradual curing of the asphalt resulted in a reduction of water discoloration and a change in the color of water from its characteristic amber to a yellow-green. It was, however, impossible at that time to eliminate or reduce the color with activated carbon even at laboratory scale. It is possible that at first most of the simpler hydrocarbons that are soluble in water were dissolved by the rainfall; the fraction that dissolved after partial curing of the asphalt consisted of more complex hydrocarbons or organic molecules. Evidently, the nature of the organic substances that produced discoloration of the water after partial curing of the asphalt was different and such that it was unaffected by the adsorbing capacity of the activated carbon. This might explain in part why it was not possible to reduce the color at that time. Another possibility is that the type of activated carbon that was used satisfactorily at first was not the correct one to remove the substances that were imparting the color at the later time. Because this material is somewhat selective in its adsorption of organic substances, the use of different types of activated carbon was proposed. Different types of activated carbon, for example, are used in removing chemical-warfare poisons from water (*4*). Unfortunately, limitations of personnel, time, and facilities did not permit a more thorough investigation.

Asphalt Mix for Catchment Areas

Further investigations, as well as correspondence with various research institutes, disclosed that, because of its slowness in curing, the cutback asphalt used was not the correct type for rain catchment basins. There are some asphalt mixes and materials suitable for this work. Some of these are listed below.

1. *Asphalt hot mix* for rain catchment areas is 50–90 per cent sand, 0–42 per cent small stone or gravel, and 8–10 per cent 85–100 pen asphalt. The mix is spread at as high a temperature as possible, but not exceeding 325°F and it is rolled with a hand or mechanical roller. It should be laid in 1½–2-in. courses without any kind of a base.

2. *Asphalt cold mix* is 45–75 per cent sand, 0–33 per cent small stone or gravel, 7–10 per cent portland ce-

ment and water. These are mixed together until all the cement and aggregate are wet. The emulsified asphalt is then added and mixing is continued until well done. The mix is then spread in 1½–2-in. thickness. Because the mix may shrink within 1–2 hr and cracks as large as half-inch may appear, a slurry mix of sand, cement, emulsified asphalt, and water should be prepared in the same proportions as above. The slurry is broomed over the surface, filling the cracks, which will not reappear.

3. *Asphalt panels* for rain catchment basins provide a simpler method, although it is more expensive than the preceding two and consists in the laying of special asphalt panels on the catchment basin. The area to be covered should be smooth and clear of sharp objects. The panels, which may be obtained in different sizes according to need, are laid and joined with a cementing material supplied by the manufacturer.

4. *Cement lining or gunite cover* has also been used satisfactorily on rain catchment basins.

TABLE 1

Analysis of Treated Water in November 1955

Constituent*	Concentration *ppm*	Recommended USPHS Maximum *ppm*
Chlorides as Cl^-	450.0	250.0
Iron as Fe^{+++}	0.8	0.3
Total dissolved solids	831.0	500–1,000

* Color (platinum–cobalt scale), 70; recommended USPHS maximum, 20.

Mineral Concentrations

Because these isolated islands are very small, the rain catchment basins are necessarily located near the shoreline. Salted air is in constant contact with the rain catchment basin, and the ocean vapors and sprays carried inland by the wind deposit minute mineral particles which constantly build up, are dissolved by the rainfall, and are transported via water to the raw water tanks. The concentration of minerals in the water varies inversely with the amount of rainfall on the catchment basin. This fact is especially noticeable during the rainy season, when the mineral concentration in the potable water is at a minimum. Consequently, during periods of low rainfall the concentration of minerals increases, at times above the recommended USPHS limits. This happened in November 1955, when four constituents were above the recommended standards.

One year later the treated water on this island was analyzed and all its mineral constituents were found to be within acceptable limits, the heavy rainfall during the rainy season being of evident help. The chemical analyses indicated that the concentrations of minerals in the water supply and in sea water (*5*) are definitely related in chemical pattern, as shown in Table 2.

It appears from Table 2 that the raw and treated waters are similar to a synthetic water prepared in proportions of 1:99 and 1:154 of sea and distilled water respectively. It should be noted that there is a greater similarity in the concentration of those ions whose origins are compounds of higher solubilities, that is, chlorides, sulfates, sodium, and potassium, than those whose origins are compounds of lower solubilities. The presence of an excess of hardness is attributed to the dissolving action of the rain water on the uncovered corals present on the catchment basin; the slightly lower magnesium content is attributed to natural

precipitation in the storage tanks. Gunite-covered catchment basins also show a higher concentration of calcium. The iron content is also higher, probably because of the presence of this element on the catchment basin. The addition of distilled water from the evaporator units has caused a lower concentration of solids in the treated water than in the raw water.

It is possible that if the chloride ion concentration is controlled to the maximum limit recommended by the USPHS, that is, 250 ppm, all the mineral constituents may be controlled to concentrations below the maximum recommended limits, and thus good quality water with practically no mineral taste may be obtained. The test for chloride ion, which may be determined by the Mohr method, requires only a simple titration and may be performed by nontechnical personnel once the standard silver nitrate solution is prepared. This test can be used as a guide in the determination of the chemical quality of the water as well as its approximate mineral content by calculations in proportions of the minerals present in the typical analysis of sea water.

If a chloride ion concentration of 250 ppm is considered acceptable, the minimum amount of distilled water to be added to the treated water tanks may be calculated from the formula

$$\Delta V = V_1 \ (0.004 \ C - 1)$$

where: ΔV is the volume of distilled water to be added in gallons; C is the chloride ion concentration of the original water, in parts per million; and V is the volume of water to be corrected, in gallons.

If Eq 1 is to be used C must be greater than 250.

TABLE 2

Comparison of Raw and Treated Waters With Typical Sea Water

Constituent	Sea Water	Content ppm		Percentage of Mineral Content of Sea Water	
		Raw	Treated	Raw	Treated
Hardness as $CaCO_3$	6,464	115	69	1.75	1.07
Calcium as $CaCO_3$	1,049	68	42	6.48	4.00
Magnesium as $CaCO_3$	5,415	45	29	0.83	0.53
Chlorides as Cl^-	19,324	198	128	1.02	0.66
Sulfates as SO_4^{--}	2,696	26	17	0.96	0.63
Sodium and potassium as Na^+	11,104	112	72	1.01	0.65
Total dissolved solids	36,000	394	236	1.09	0.65

The amount of water to be added may be also estimated by the nomograph in Fig. 2, which is based on Eq 1.

Corrosion of Water Mains

Rain water is corrosive because of its low mineral content, the presence of the dissolved gases it absorbs in the atmosphere and its undersaturation of calcium carbonate with respect to its chemical stability point. Thus, the degree of corrosiveness of the water at similar islands with rain catchment areas located near the sea depends on the amount and character of the minerals present, on the dissolved gases

it contains, and on its chemical stability. The relatively high concentration of electrolytes probably accounts for a larger share of the corrosiveness of this water than the action of the dissolved gases and the calcium and carbonate ions. The chemical stability

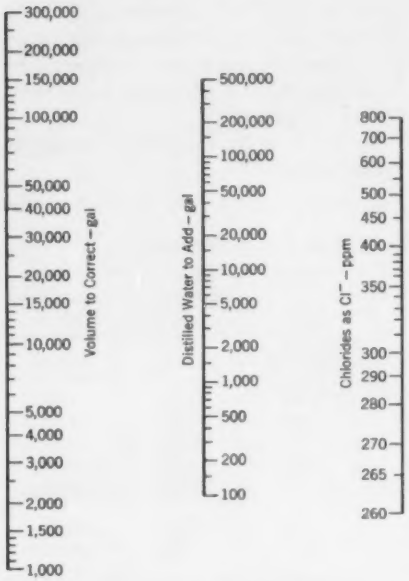

Fig. 2. Nomograph for Determination of Distilled Water Necessary to Reduce Chloride-Ion Concentration to Acceptable Maximum

This nomograph is based on Eq 1 (in text). It may be read by laying a straightedge across the scales and reading values at its point of intersection with each scale.

of the water in respect to the calcium carbonate saturation point as defined by the Langelier theory would not necessarily apply because of the concentration of electrolytic ions present. At these facilities, for example, the Langelier index has varied from a negative value of 1.9 to a positive one of 0.2, but the water has retained its aggressive characteristics even when the Langelier index has been positive. Because of the high concentration of electrolytic ions, stabilization of the water to its chemical stability point might be of help to decrease, but not prevent its aggressive properties. Waters with chloride ion concentrations of more than 100 ppm are usually corrosive (*6*).

One thing that helps to bring the water to near chemical stability is the calcium carbonate dissolved by the rain water from the coral present on the catchment basin. But tests indicate that most of the time these dissolved carbonates are unable to reach the stability point, probably because of the low solubility of the impure calcium carbonate that composes the coral and because most of the coral is covered with the asphaltic coating previously described.

The problems of corrosion of water lines and of the occurrence of "red water" are common in the Bahamas. Threshold treatment with polyphosphates was recently started at one of the islands in order to form a monomolecular film on the interior of the water pipes which may protect them from corrosion. Unfortunately, the time elapsed since the beginning of this application has been insufficient to offer conclusive evidence of the protective action afforded by the polyphosphates in this water, and apparently no research work has been undertaken to evaluate the effectiveness of these inhibitors in waters of this nature.

Corrosion is a problem in the Bahamas. Because of the wide range of variations in water quality, the high concentration of electrolytes, and vari-

able mineral concentration, it would be desirable that asbestos-cement or cement-lined pipe be used in the construction of every new facility. The same should be used when replacement of the present cast-iron pipe is required.

Further Studies

Further studies with this type of water are desirable to explore its corrosive properties. It would be easy to duplicate the water characteristics at the laboratory because of its proportional chemical pattern with sea water. A research work with this type of water should furnish data and criteria to facilities with similar problems. The research data may be obtained by exposing low-carbon steel plates, cast iron, or other desired materials to the action of the water at a constant velocity.

A similar corrosion research project using several types of natural waters is presently in progress. Its main purpose is to gain a more thorough knowledge of the effect of the calcium carbonate in waters on their corrosiveness (*7*).

Conclusions

1. Special asphalt that will not produce discoloration of water or some other material, such as gunite, should be used to cover rain catchment basins.

2. Discoloration produced in water by asphaltic constituents may be adsorbed by various types of activated carbon.

3. An approximate mineral analysis of the water at naval facilities or islands with rain catchment basins located near the seashore may be obtained through a simple chloride ion test. The minerals present in the water can be estimated by comparing the proportions of chlorides with respect to their concentrations in typical sea water.

4. If the chloride ion concentration of the water is below the maximum recommended USPHS limit of 250 ppm, it is probable that all the mineral constituents are within standards.

5. Asbestos-cement or cement-lined pipe should be used at facilities with rain catchment basins located near the sea.

6. More research work is desirable in order to obtain a better understanding of the behavior of this type of water. Synthetic waters with mineral concentrations similar to those of these facilities can be easily prepared in the laboratory.

References

1. Drinking Water Standards. *Pub. Health Repts.* Reprint No. 2697, USPHS, Washington, D.C. (Mar. 1946).
2. Abraham, H. *Asphalts and Allied Substances.* D. Van Nostrand Co., Inc., New York (5th ed., 1945).
3. Lowe, H. N. Corps of Engineers' Development of Field Water Supply Equipment. Report of the Symposium on Advanced Base Water Supply and Sanitation. US Naval Civ. Eng. Research and Evaluation Lab. (Oct. 1953).
4. *Preventive Medicine in World War II—Volume 2, Environmental Hygiene.* US Army Medical Dept., Washington, D.C. (1955).
5. Nordell, E. *Water Treatment for Industrial and Other Uses.* Reinhold Publishing Corp., New York (1951).
6. Powell, S. T. *Water Conditioning for Industry.* McGraw-Hill Book Co., Inc., New York (1954).
7. Stumm, Werner. Corrosion Studies Research at Harvard University. *Public Works,* **88**:12:78 (1957).

Discussion

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The subsurface in Nassau and Suffolk Counties, Long Island, consists of successive layers of sand and gravel above a rock floor. These layers of aquifers are of considerable magnitude and have tremendous storage capacity. All public water is pumped from wells. These formations, however, differ from those in the Caribbean. It may be of interest to describe briefly some experiences on Long Island and the conservation methods successfully used.

Over 23 years ago the Board of Supervisors of Nassau County were cognizant of the diminishing water supply. In anticipation of continued population growth, the board authorized the development of a long-range master drainage and water conservation plan in 1936 which was prepared under the author's direction.

In order to provide for its future needs and replenish its ground water storage, the county has been engaged since the year 1935 in the construction of large-acreage, artificial, storm water recharge basins to replenish the ground water storage. Under the long-range drainage and conservation program, 405 recharge basins have been developed with successful performance. In Suffolk County over 400 storm water recharge basins have been developed.

In Nassau County it is estimated that there is approximately 40 mgd storm water runoff, and in Suffolk County an annual average of approximately 10 mgd of rainfall runoff replenishes the ground water storage. The future development of Suffolk County may ultimately bring this to 50 mgd and of Nassau County to 70 mgd.

Current efforts to conserve ground water supplies include recharge basins an acre or more in size, storm water diffusion wells, diffusion wells for cooling and air-conditioning, industrial-waste treatment and reuse, and governmental study and control.

Analyses of samples of water from several storm water storage basins indicate that chlorides varied 2–4 ppm, iron 0.1–0.8 ppm, and dissolved solids 132–218 ppm. At one of the recharge basins the phenol concentration was 0.01 ppm. This is reduced to a negligible amount by dilution when the recharge water seeps into the ground water table below the bottom elevation of the recharge basins.

When phenols are present they probably originate from the storm water runoff where street pavements in the tributary watershed area are surfaced with bituminous tar material. No phenol is present where there is asphaltic surface treatment.

The analysis shows that the chlorides and dissolved solids are within the requirements of the USPHS standard for drinking water.

As far as pathogenic bacteria are concerned, filtration through the subsurface sand would remove them.

There has been no indication of bacteriological or chemical contamination in any of the county's public water supply wells located in proximity to artificial recharge basins. There are over 616 wells in the 50 public water supply systems, consisting of villages, water districts, and private companies.

Logging Roads in Northeastern Municipal Watersheds

George R. Trimble Jr.

A contribution to the Journal by George R. Trimble Jr., Research Forester, Northeastern Forest Experiment Station Research Center, Elkins, W.Va.

FOREST growth covers most of the the municipal watersheds in the northeastern United States (*1*). These forests produce marketable wood products the sale of which may be an important source of income to the owner of the watershed. This in itself is a good reason for harvesting timber from watershed forests. Another reason for cutting timber is to reduce the amount of vegetation using up water. If this is done without causing an increase in surface runoff and erosion it *may* result in an increased water supply. (The possibilities of this type of vegetation manipulation, however, depend upon a complex interrelationship of factors; a decision to reduce forest growth in order to provide more water should be made only after consultation with watershed-management specialists.)

Sedimentation Hazard

Regardless of the reason for logging a municipal watershed the operation itself can constitute a hazard to the quality of the water supply. If the timber could be felled and sawed into logs on the spot and the logs transported by air to a point outside the watershed then the risk of impairing water quality would be slight. Today, however, such logging methods exist only as a future possibility. In the Northeast most logging is done with tractors and trucks, which require roads, and roads on a watershed may be sources of sediment in the water supply. This sediment can reduce reservoir storage capacity, clog intake pipes, either lower water quality or increase filtration costs, and damage the habitat of useful aquatic life.

Logging a municipal watershed has, therefore, often been considered a risky venture. Many municipalities have foregone income and possible additional water supplies rather than risk sedimentation of the water system. The hazard of sedimentation as a result of logging may, however, be practically eliminated if the location, construction, and maintenance of logging roads are in accordance with recommendations developed through studies of this problem.

Recommendations

The Northeastern Forest Experiment Station, Upper Darby, Pa., of the US Forest Service has made studies to determine the logging-road standards that will minimize erosion and protect water supplies and also facilitate efficient logging. Many of these studies have been made in the Fernow Experimental Forest in West Virginia; others are being made in

New Hampshire. State highway departments and the national forest authorities have also contributed materially to present knowledge of how to prevent erosion of logging roads.

There are two aspects of this problem: erosion from the road surface and adjacent disturbed areas, such as cut-and-fill slopes, and the resulting sedimentation. If roads did not erode they could not be a source of sediment; if there were road erosion but none of the eroded material reached the water supply there would also be no sediment problem.

Both aspects have been studied; the results form the basis of the following recommendations. These recommendations, when adapted to the problems of an individual watershed concerned, should provide satisfactory safeguards for logging operations on most municipal watersheds in the Northeast.

Reducing Erosion

1. The maximum grade on truck roads and bulldozed or heavily used skid trails should be less than 10 per cent, except for very short stretches where a larger grade may be necessary for reasons of economy. Roads and trails with grades between 5 and 10 per cent can be drained adequately and will not erode badly and log transportation on these roads is economical.

2. Logging roads should be drained adequately. This will prevent surface water on the road from building up an erosive force. To drain a road or trail that is not crowned and ditched—and logging roads almost never are—cross-drainage should be provided at frequent intervals. Such drainage may take the form of open-top culverts, broad dips made with a bulldozer or a grader blade, or dug or log water bars. Open-top culverts or dips can be used on truck roads during logging operations. On tractor roads or skid trails the open-top culverts must be installed with special care or they may be ripped out; dips are effective and require less care to install. Water bars should be constructed only after use of a road or trail has ceased.

A rule of thumb often used to determine the required spacing of surface cross-drainage is to divide 1,000 ft by the percentage of grade of the road. Thus, a 10 per cent grade road would need drains at 100-ft intervals. After the roads are built care should be taken to provide correctly located cross-drainage to compensate for springs and seepage water brought to the surface by the road cut. Maintenance of drainage structures during logging operations is important. Care should be taken to keep all culverts functioning because a plugged culvert can cause a badly eroded gully. In some soils, dips that carry large amounts of water will wash badly. This can often be prevented by spreading clean gravel in the dip. Road-surface erosion will be diminished by frequent breaks in the grade of the road.

3. Roads in draws and roads cut below the ground surface cannot be adequately drained. Therefore, they should, if possible, be located on a side slope. Very steep side slopes should be avoided, however, because of the hard-to-stabilize banks that result and also because road building on steep sidehills is expensive.

4. After the logging job is finished the roads and trails should be stabilized so that the erosion hazard is greatly reduced or entirely eliminated. Temporary bridges and open-top culverts that are likely to plug up with debris

should be dismantled. Open-top culverts should be replaced with water bars. Badly rutted roads should be graded and a slight outslope should be given to the road surface. All sections of road surface and all bare banks that are eroding or appear susceptible to erosion should be seeded with grasses.

5. The risk of stream pollution from eroding logging roads and trails will increase with the length of the logging operation. Thus, the sooner the job is finished and stabilization measures are begun the shorter will be the period of greatest erosion hazard. For this reason logging should be started in the more remote wooded areas first and as soon as any one trail or road section is no longer needed it should be stabilized.

6. Weather conditions should be taken into consideration. Road-building, skidding, and hauling should be restricted as far as possible to periods of good weather. Such operations, if performed during rainy weather or when muddy conditions prevail, will greatly increase the risk of erosion.

7. In cold regions where a winter snowpack builds up each year logging on snow roads is an excellent safeguard against erosion.

Reducing Sedimentation

1. Roads and trails should be located away from stream courses, except where a stream crossing cannot be avoided. The object of this is to provide an opportunity for the sediment from road runoff to be filtered out by the forest floor before it can reach a stream. Some work done in New Hampshire can serve as a guide to how far from stream courses logging roads should be located to provide adequate filtering out of sediment (*2*). In brief: starting with an arbitrary filter strip of 50 ft between road and stream in flat terrain the width of this filter strip should be increased by 4 ft for each 1 per cent increase in grade of the terrain. Thus, on a 20 per cent grade slope the road should be located approximately 130 ft away from the stream. It is to be expected, of course, that different types of soil might require some modification of this rule-of-thumb. Also, the use of water-spreading devices below road-drainage outlets will safely permit leaving a narrower filter strip.

2. Logging operations should not be carried on near or across a stream. Trees cut below the road should be moved uphill with a winch. Keeping logging operations away from the stream has two important results: it prevents disturbance of the soil near the stream and it keeps tops and limbs of trees from plugging the channel and causing damming and bank-cutting during high flows.

3. With truck roads all water courses, even small springs and seepage channels, should be crossed on closed culverts or bridges. This keeps the water out of the road and prevents vehicles from stirring up mud in the stream channel.

4. Stream crossings should be approached at a right angle or if necessary from above, never from below where an opportunity might be presented during periods of high water for the stream to wash down the road.

Planning the Roads

With these recommendations in mind the official in charge is ready to plan and lay out the logging-road system. Control points such as stream crossings, rock ledges, and stands of marketable timber should be indicated

on a good contour or aerial map of the watershed. Care should be taken in laying out the road to provide adequate accessibility to the logging area with the minimum road mileage.

Precautions

Two special situations should be considered:

1. The recommendations given in this article may not prevent pollution during extremely heavy rainstorms or major floods. Some sedimentation can generally be expected under these conditions. If the recommendations are followed, however, the amount and duration of such sedimentation should not be unduly increased by logging.

2. Supervision must be adequate to insure that the safeguards of water quality are maintained throughout the logging operation. The recommendations contain some provisions that it will not come naturally to the average logging operator to follow. Without strong guidance he is likely to take many of the recommendations lightly. Also, under some conditions costs not involved in the normal logging operation will have to be incurred. These things should be understood from the beginning by all concerned to insure safe road building and timber removal on a municipal watershed.

References

1. Lull, H. W. Municipal Watersheds in the Northeast. *Jour. AWWA,* **50**:979 (Jul. 1958).
2. Trimble, G. R., Jr. & Sartz, R. S. How Far From a Stream Should a Logging Road Be Located? *J. Forestry,* **55**:339 (1957).

Determination of Calcium, Magnesium, and Total Hardness by Automatic Spectrophotometric Titration

Howard V. Malmstadt and T. P. Hadjiioannou

A contribution to the Journal by Howard V. Malmstadt, Assoc. Prof., and T. P. Hadjiioannou, Research Asst., both of the Dept. of Chemistry and Chem. Eng., Univ. of Illinois, Urbana, Ill.

IT was recently shown (*1*) that calcium and magnesium in dolomites and limestones can be determined rapidly and accurately by an automatic spectrophotometric-titration procedure using ethylenediaminetetraacetic acid (EDTA) titrant. Results are now presented which show that the same automatic procedure is well suited for the determination of calcium and magnesium in both hard and soft waters.

The method is extremely simple and rapid. An aliquot of the water sample is pipetted into a beaker, suitable buffer solution and Eriochrome black T indicator is added, the beaker is inserted into a new, commercially available titrator,* the automatic start button is pressed, and the titration for total calcium and magnesium is automatically terminated at the endpoint. Calcium can be determined by pipetting another aliquot of water sample into a beaker, adjusting to about pH 13 with NaOH to precipitate the magnesium, adding Calcon † indicator (*2*), inserting the beaker into the titrator, pressing the start button, and reading the buret after automatic termination at the end point. Magnesium is determined by subtracting the amount of calcium determined in one aliquot from the total amount of calcium and magnesium determined in the other aliquot.

The titrations are completed rapidly, requiring from a few seconds to a few minutes, depending on the water hardness. For example, a sample of hard water having 300 ppm total hardness requires about 2 min, and a sample of soft water of 3 ppm hardness requires about 10 sec for the automatic titration. Less than a minute is needed for manipulation of the sample prior to titration. Separate analyses for calcium and magnesium in natural waters can both be completed in less than 5 min.

Titrations of calcium and magnesium with EDTA are, of course, now well established. Following the original work of Schwarzenbach and Biedermann (*3*), Diehl, Goetz, and Hach (*4*) determined both calcium and magnesium by a method based on the titration of total calcium and magnesium with EDTA, and the titration of magnesium after precipitation of calcium as calcium oxalate, with the calcium determined by difference.

Schwarzenbach, Biedermann, and Bangerter (*5*) used a saturated solution of ammonium purpurate (murex-

* Spectro-Electro; a product of E. H. Sargent Co., Chicago, Ill.

† Cl 202; a product of J. T. Baker Chemical Co., Phillipsburg, N.J.

ide) as an indicator for calcium. Betz and Noll (*6–8*) studied the direct EDTA titration for the determination of water hardness using murexide and Eriochrome black T as indicators. These procedures were more rapid than the conventional gravimetric methods (*9*), which involve time-consuming precipitations and separations. The manual–visual endpoint detection method, however, has given some difficulty. The endpoints are quite sharp, but there are ranges of color change within which a selection must be made. When Eriochrome black T indicator is used, Connors (*10*) recommends the use of an artificial color standard. Aconsky and Mori (*9*) applied a spectrophotometric technique to improve endpoints in the EDTA titration of calcium in which murexide is used as indicator.

The use of the automatic endpoint termination makes subjective evaluation unnecessary and provides excellent reproducibility, within 0.01 ml of 0.01*M* EDTA solution. The automatic-titration results check closely with known samples.

Apparatus

The spectrophotometric, derivative titrator was used. The standard photoconductive circuit and light source for the instrument were used and the polarity and filter positions were set. For natural waters a 10-ml, self-zeroing, plastic * stopcock buret was used. It was filled with EDTA titrant from an elevated polyethylene bottle through the side arm which was fitted with a plastic stopcock, and all interconnections were made with polyethylene tubing, except for the short piece of gum rubber tubing that connected the upper end of the instrument's delivery tip to the buret tip via the buret valve. For low-hardness waters a 5-ml buret already equipped with plastic delivery and refill stopcocks and a reservoir was used.

* Teflon; a product of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Reagents

A standard calcium solution was prepared by drying primary standard calcium carbonate in an oven overnight at 110°C. Exactly 1.000 g is placed in a liter flask with about 200 ml of twice-distilled or, preferably, deionized water; 20–22 ml of 1.0*M* HCl are added to the flask, which is then heated on a hotplate to about 70°C until evolution of carbon dioxide. After the flask is cooled to room temperature, it is filled to the mark with deionized water. One milliliter of this standard solution represents 1.000 mg $CaCO_3$ or 0.4004 mg of calcium.

To prepare the EDTA solution, dry the disodium salt of ethylenediaminetetraacetic acid dihydrate at 80°C. Dissolve 3.720 g of the dried salt in deionized water and dilute to 1 liter. Standardize this solution against the standard calcium solution and store it in polyethylene bottles.

A magnesium solution is prepared by dissolving approximately 2.465 g of magnesium sulfate heptahydrate in a liter of distilled water. Standardize the solution with EDTA using Eriochrome black T as indicator.

Indicators used are a calcium indicator prepared by dissolving 0.2 g of Calcon indicator in 50 ml of methanol, and a total calcium and magnesium indicator (EBT), prepared by dissolving 0.2 g of Eriochrome black T in 50 ml methanol.

To prepare a buffer solution, 67.5 g of reagent grade ammonium chloride and 570 ml of cp concentrated ammonium hydroxide are diluted to a liter with distilled water.

Also used are sodium hydroxide, 1.0*N* aqueous solution, and potassium cyanide, 10 per cent aqueous solution.

Procedures for Natural Waters

The titrator is switched to the "Spectro" position; the polarity switch thrown to Position 2; the filter wheel turned to the 650-mμ position; the pegs in the base set to position the 50-ml beakers properly; the small stirrer, delivery tip, and suitable buret are connected and the titrant delivery rate is set at about 3 ml/min. The same conditions are suitable for both endpoints.

To standardize the titrant, pipet a 5-ml aliquot of standard calcium solution into a 50-ml beaker; dilute to about 20 ml with deionized water; adjust to pH 13 by adding 1*N* NaOH (test with pH paper); add 1–2 drops of Calcon indicator; insert the beaker in automatic titrator; push the start button to start stirring and delivery of titrant; and read the buret after automatic termination at the end point.

To determine total hardness pipet a 20-ml aliquot of the water sample into a 50-ml beaker. Add 2 ml of the buffer solution and 3–4 drops of the potassium cyanide solution, insert the beaker into the titrator, and start the stirrer to mix the masking agent with sample. Then add 2 drops of the Eriochrome black T solution and titrate the solution by pushing the starter button on the derivative control unit. The buret is read after automatic termination at the endpoint.

TABLE 1

Automatic Titration Results for Samples Containing Known Amounts of Calcium and Magnesium

Sample No.	Calcium *ppm*			Magnesium *ppm*			Total Hardness as $CaCO_3$ *ppm*		
	Actual	Found	Difference	Actual	Found	Difference	Actual	Found	Difference
1	48.0	48.0	0.0	—	—	—	120	120	0
2	48.0	48.1	+0.1	10.0	10.1	+0.1	161	162	+1
3	48.0	48.0	0.0	30.0	29.9	−0.1	243	243	0
4	48.0	47.8	−0.2	50.0	50.0	0.0	326	325	−1
5	160.0	159.9	−0.1	—	—	—	400	400	0
6	160.0	160.1	+0.1	10.0	10.2	+0.2	441	442	+1
7	160.0	160.0	0.0	20.0	20.2	+0.2	482	483	+1
8	160.0	159.8	−0.2	50.0	49.8	−0.2	606	605	−1

To determine calcium hardness, pipet a 20-ml aliquot of the water sample into a 50-ml beaker. Add 1*N* NaOH to bring the pH of the solution to 13 (2.5 ml is usually required; use pHydrion * paper for the estimation of pH). Add 3–4 drops of the potassium cyanide solution; insert the beaker into the titrator; and mix by stirring. Add 1–2 drops of the Calcon indicator solution and push the automatic start button. The buret is read after the titra-

* A product of Micro Essential Lab., Brooklyn, N.Y.

tion is automatically stopped at the endpoint.

Magnesium hardness is calculated by subtracting the calcium hardness from the total hardness.

Calculations

When a 20-ml water sample is taken for titration, calcium, magnesium, and total hardness can be calculated as follows:

$A \times B \times 50 =$ ppm calcium

$C \times (D - B) \times 50 =$ ppm magnesium

$D \times E \times 50 =$ ppm total hardness ($CaCO_3$),

where,

A = milligrams calcium per milliliter EDTA solution, which is equal to 2.0022 divided by milliliters EDTA used in standardization titration,

B = milliliters EDTA solution used in titration, with Calcon as indicator,

C = milligrams magnesium per milliliter EDTA solution, which is equal to 1.215 divided by milliliters EDTA used in standardization titration,

D = milliliters EDTA solution used in titration, with Eriochrome black T as indicator, and

E = milligrams calcium carbonate per milliliter EDTA solution, which is equal to 5.00 divided by milliliters used in standardization titration.

Results and Discussion

Analyses of solutions containing known concentrations of calcium and magnesium in different amounts and in different ratios gave the results shown in Table 1. The absence of interfering ions in this case made unnecessary the addition of masking agents. The maximum error was 0.2 ppm for calcium and magnesium, and 1.0 ppm for total hardness.

The method has been applied for a large number of natural waters. A few typical results are shown in Table 2, which is a comparison between gravimetric determinations made in the course of routine laboratory work

TABLE 2

Comparison of Automatic Titration and Gravimetric Results for the Determination of Calcium and Magnesium in Natural Waters

Sample No.	Calcium *ppm*			Magnesium *ppm*			Total Hardness as $CaCO_3$ *ppm*		
	Gravimetric Analysis	EDTA Analysis	Difference	Gravimetric Analysis	EDTA Analysis	Difference	Gravimetric Analysis	EDTA Analysis	Difference
1	64.5	65.0	0.5	9.6	9.9	0.3	201	203	2
2	65.5	65.6	0.1	43.1	43.6	0.5	341	343	2
3	75.5	75.6	0.1	41.6	41.5	0.1	360	360	0
4	90.5	90.2	0.3	56.2	55.9	0.3	457	455	2
5	16.5	16.5	0.0	5.7	6.0	0.3	65	66	1
6	57.0	56.3	0.7	21.5	21.8	0.3	231	230	1
7	73.5	73.4	0.1	25.5	25.4	0.1	287	287	0
8	87.0	86.0	1.0	34.9	35.0	0.1	361	359	2
9	16.0	16.1	0.1	6.7	6.2	0.5	68	66	2
10	77.0	77.2	0.2	36.7	35.9	0.8	343	340	3

and the automatic titration method. The waters tested had total hardnesses ranging from 65 to 455 ppm ($CaCO_3$). As can be seen from Table 2, there is close agreement between the two methods. The maximum difference between the two methods is 1.0 ppm for calcium, 0.8 ppm for magnesium, and 3 ppm for total hardness.

The delivery rate of the titrant was adjusted in the range of about 3 ml/min for the standardization of the EDTA solution and all the titrations of calcium and magnesium in Tables 1–3. Faster titrant delivery rates are possible, but they cause slight overshooting of the equivalence points, which necessitates blank corrections.

The method was also tested on a number of water samples prepared from standard limestone and dolomite samples. Gram samples were digested in perchloric acid (*1*) and diluted—after the filtration of silica and the R_2O_3 group—to exactly 500 ml. Aliquots of 5 ml were then diluted and analyzed. The results obtained are given in Table 3, which shows the good reproducibility of the automatic titration. This reproducibility is typical of results obtained for all water samples.

Ionic interference from heavy metals that may be present is masked by adding potassium cyanide. In synthetic waters prepared from NBS Limestone 1a, ascorbic acid was added for reduction of any Fe (III) and the solution was heated to about 40–50°C prior to pH adjustment and the addition of cyanide.

Low-Hardness Waters

A lower concentration of titrant and a larger volume of water sample are required for the low-hardness waters in order to obtain good results. It was found that a 0.0025*M* EDTA solution was a satisfactory titrant, but it was necessary to increase the titrant delivery rate to about 8 ml/min in order to provide a signal from the titrator that was sufficient to terminate the titration automatically. This high flow rate causes an overshooting of the equivalence point, but it is very reproducible and a blank correction is easily applied. A blank of 0.12 ml, equivalent to 0.3 ppm $CaCO_3$ hard-

TABLE 3

Automatic Titration Results for Synthetic Hard Waters Prepared From Standard Limestones and Dolomites

Sample	Calcium *ppm*			Magnesium *ppm*			Total Hardness as $CaCO_3$ *ppm*		
	Avg EDTA Value	Calculated Value	Avg Deviation	Avg EDTA Value	Calculated Value	Avg Deviation	Avg EDTA Value	Calculated Value	Avg Deviation
NBS Limestone 1a	295.0	295.2	0.5	21.5	21.7	0.2	316.5	316.9	0.5
NBS Dolomite 88	217.6	217.8	0.4	212.5	213.1	0.2	430.1	430.9	0.4

ness, was always subtracted from the volume of EDTA used in the titration by the low-hardness procedure.

An attempt to determine separately the calcium and magnesium hardnesses of low-hardness waters gave high results for calcium hardness and low results for magnesium hardness, because of the incomplete precipitation of magnesium as magnesium hydroxide when present in very low concentrations (less than 1.0 ppm). Therefore, only total hardness as $CaCO_3$ was determined for low-hardness water.

TABLE 4

Automatic Titration Results for the Determination of Low Hardness

Hardness* as $CaCO_3$ ppm		
Present	Found	Difference
10.0	9.8	−0.2
5.0	4.9	−0.1
3.7	3.7	0.0
2.5	2.6	+0.1
2.0	2.1	+0.1
1.3	1.4	+0.1
1.0	1.1	+0.1
0.5	0.6	+0.1

* Calcium, 62 per cent; magnesium, 38 per cent.

The titrator is set up in the same way as for natural waters except that the pegs in the base are set for a 200-ml beaker, a stirrer of the correct size for efficient stirring of 100 ml of water is inserted, and the 5-ml buret with plastic stopcocks and reservoir is placed in position and the flow rate is adjusted to 8 ml/min.

For low-hardness waters, close the stopcock on the buret, and pipet 100 ml of the water sample into a 200-ml beaker. Add 3 ml of the buffer solution and 3–4 drops of the potassium cyanide solution, and mix by stirring. Add 3–4 drops of the Eriochrome black T solution, push the automatic-start button and open the stopcock after the 10-sec time-delay relay is closed. The titration is automatically terminated within a short time, often just a few seconds, and the buret is then read.

Subtract 0.12 ml from the EDTA volume used in the titration and multiply the difference by 2.5 to obtain the total hardness in parts per million calcium carbonate. Table 4 gives the values obtained over a range of 0.5–10 ppm hardness. The average disagreement between the known and experimentally found values is about 0.1 ppm.

Instead of manipulating the stopcock on the buret, as above, in order to be sure that the titrator is activated before the end point is reached, one may replace the 10-sec, safety, time-delay relay with a 2-sec time delay. This is a plug-in unit and is easily changed. In general it is best to operate with the 10-sec time-delay safety, but it is not essential if the stirring has been started and solution thoroughly mixed before the automatic start button is pushed.

Summary

A direct, automatic spectrophotometric EDTA titration for calcium and magnesium hardness has been described. Calcium is determined in the presence of magnesium at pH 13 using Calcon as indicator. The total amounts of calcium and magnesium are determined at pH 10 using Eriochrome black T as indicator. Both titrations are automatically terminated at their equivalence points, and the subjective evaluation of endpoints is eliminated. Interference by heavy metals is pre-

vented by adding a few drops of potassium cyanide. The automatic-titration method was applied to more than a thousand samples with total hardness from 0.5 to 600 ppm, and the results were very reproducible and accurate. The time required for an automatic titration varies from a few seconds to a few minutes, depending on the water hardness. Sample preparation and manipulation and buret reading require less than a minute per water sample.

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References

1. MALMSTADT, H. V. & HADJIIOANNOU, T. P. Rapid and Accurate Automatic Titration of Calcium and Magnesium in Dolomites and Limestones. *Anal. Chim. Acta* (in press).
2. HILDEBRAND, G. P. & REILLEY, C. N. New Indicator for Complexometric Titration of Calcium in Presence of Magnesium. *Anal. Chem.*, **29**:258 (1957).
3. BIEDERMANN, W. & SCHWARZENBACH, G. The Complexometric Titration of Clay Alkalis and Some Other Metals with Eriochrome black T. *Chimia* (Ger.), **2**:56 (1948).
4. DIEHL, H.; GOETZ, C. A.; & HACH, C. C. The Versenate Titration for Total Hardness. *Jour. AWWA*, **42**:40 (Jan. 1950).
5. SCHWARZENBACH, G.; BIEDERMANN, W.; & BANGERTER, F. New Simple Titration Methods for the Determination of Water Hardness. *Helv. Chim. Acta* (Ger.), **29**:811 (1946).
6. BETZ, J. D. & NOLL, C. A. Total-Hardness Determination by Direct Colorimetric Titration. *Jour. AWWA*, **41**:982 (Nov. 1949).
7. BETZ, J. D. & NOLL, C. A. Total-Hardness Determination by Direct Colorimetric Titration. *Jour. AWWA*, **42**:49 (Jan. 1950).
8. BETZ, J. D. & NOLL, C. A. Further Studies With the Direct Colorimetric Hardness Titration. *Jour. AWWA*, **42**:749 (Aug. 1950).
9. *Standard Methods for the Examination of Water, Sewage and Industrial Wastes.* APHA, AWWA, & FSIWA, New York (10th ed., 1955).
10. CONNORS, J. J. Advances in Chemical and Colorimetric Methods. *Jour. AWWA*, **42**:33 (Jan. 1950).
11. ACONSKY, L. & MORI, M. Spectrophotometric Technique for Calcium. *Anal. Chem.*, **27**:1001 (1955).

Hydraulic Uses for Asphalt

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A paper presented on Oct. 30, 1958, at the California Section Meeting, Los Angeles, by Carl F. Lind, Dist. Engr., The Asphalt Institute, Los Angeles.

ASPHALT is an important water-resistant material. Asphalt was the pitch which, according to the Bible, was used to calk Noah's ark and to seal the basket in which the infant Moses was set adrift on the Nile. As early as 3800 B.C. asphalt was used in the construction of watertight reservoirs, canals, and bathing pools. Many examples of this construction remain intact even today.

As early as 1893 asphalt was used for an important dam project in Italy. In the late 1920's its possibilities as a material for hydraulic construction were made a subject for systematic investigation.

What is needed for hydraulic work is a durable, economical, waterproof construction material that is readily available, easily maintained, and can withstand the constant wearing action of water. Asphalt combines all of these qualities and characteristics. Asphalt is now used extensively in such hydraulic structures as canal and reservoir linings, dam facings, storm-channel linings, highway dikes and gutters, groins, and sea walls, and also for river bank protection and jetty stabilization.

Every application of asphalt in hydraulics, whether it is used to render installations impervious or in the construction of protective works, poses civil engineering problems which can only be solved by a study of local conditions and requirements. There are, however, some guiding principles.

Buried Membrane

An inexpensive waterproof lining for the control of seepage and leakage from canals and small reservoirs is the buried asphaltic membrane. Buried asphaltic membranes are asphaltic seals which are sprayed in place and covered with a protective material such as soil, sand, or any similar covering. The cover material, which may vary in thickness from 6 in. to 2 or 3 ft, protects the membrane from air, actinic solar radiation, erosion, the hooves of grazing animals, and from equipment that may be used to clean a channel or reservoir. The asphalt membrane, protected in this way, may be expected to last for many years.

For buried membranes a steam-refined or semiblown, medium- to low-penetration asphalt with a softening point of 130–150°F is used. The asphaltic membrane must be continuous, unbroken, and free from "holidays" or open areas. This will require from 0.75 gal/sq yd of asphalt over a smooth subgrade to as much as 2.00 gal/sq yd over a very rough subgrade. Over a very rough subgrade a tough asphalt membrane, $\frac{5}{16}$–$\frac{3}{8}$ in. thick, is necessary. The membrane should ordinarily not be placed on slopes steeper than 2:1.

A buried asphalt membrane has a very high efficiency—that is to say, it will permit very little water loss. With mass construction techniques 10,000–15,000 sq yd/day can be sprayed in place and covered by a field crew of only a few men without making excessive demands on either the workmen or the equipment (Fig. 1). Construction of this type is possible during nearly all types of weather. Maintenance costs for a buried membrane are low and a long service life may be expected.

Normally, costs for a completed buried membrane are less than $1 per square yard. Large projects have cost 75 cents per square yard and by force account 50 cents per square yard.

A notable example of the use of buried membrane lining is a large canal project near Klamath, Ore., completed about 10 years ago. Other typical uses are for small irrigation reservoirs and canals, ponds in parks, water hazards on golf courses, and other similar uses. Application of the asphalt may be made by hand sprays for such uses as these.

Asphaltic Concrete

A frequent type of asphalt use in hydraulic construction, one which has become established by years of successful performance, is for hot-mixed, hot-laid asphaltic-concrete lining.

The mixture may vary greatly, depending on intended use. The asphaltic concrete may be designed either as an impermeable, watertight lining, or as a porous lining, as conditions require. When used as a porous lining some method of rendering the mixture impervious must be provided to control seepage. Compacted earth is usually used for this purpose. The porosity of the asphaltic lining relieves uplift pressures and, by allowing the water to seep back into a reservoir, prevents upheaval of the lining on drawdown of the water.

An impermeable mix should have a high percentage of asphalt, possibly between 7 and 9 per cent by weight, so that it will be as dense as possible. For reservoir linings rich asphaltic mixtures may be used because the lining will not be subjected to heavy, concentrated loads. The lining, however, must be able to resist plastic flow down the bank of the slopes under the sustained force of its own weight.

Fig. 1. Asphaltic Membrane

A catalytically blown asphaltic membrane is being sprayed onto the inner surface of a reservoir.

A porous asphalt mixture should have more large-size aggregate and a relatively smaller percentage of fines than an impermeable mixture. It need not have as much asphalt. The principal use of a porous mixture is for erosion protection of reservoirs and other installations. One such reservoir, presently under construction at Corona Del Mar for the city of Newport Beach, Calif., has a 3-in. asphaltic-concrete lining on a 3:1 slope. A porous mixture with a 60–70 penetration-grade asphalt content of 4.36 per cent is being used. This reservoir will have a capacity of about

200 mil gal. The cost of the 3 in. of asphaltic-concrete lining is 10 cents per square foot on the bottom and 11 cents on the slopes. Spreading the asphaltic-concrete mixture is done by means of a conventional spreader box pulled up the slope behind dump trucks (Fig. 2). The trucks are pulled up the slope by a tractor and a cable winch. The lining is compacted by a conventional type of tandem roller, using a 3-ton roller for initial compaction and a 5-ton roller for final compaction. Both rollers are raised and lowered on the slopes by tractors and cable winches.

Fig. 2. Asphaltic Concrete

A 3-in. thickness of asphaltic-concrete lining is being applied by slope paving to a reservoir.

If there is a serious weed condition in the locality of the reservoir or canal which is to be lined with asphaltic concrete, some form of weed control is definitely recommended by the author. There are several commercial weed killers now on the market that can be applied to the subgrade before placing the asphaltic lining.

Some of the earliest asphalt-lined reservoirs in California, constructed in the 1920's, are still giving good service. The Baldwin Hills Reservoir in Los Angeles, with a capacity of about 300 mil gal was completed in 1951. Due to geological conditions the lining of this reservoir consisted of a prime coat and a membrane seal followed by a porous drainage course, covered with a compacted earth blanket topped with a 3-in. layer of asphaltic concrete on slopes of about 2:1 and 2½:1. The prime coat consisted of several applications of light, slow-curing asphalt sprayed over the subgrade. The membrane seal consisted of two or three applications of 40–50 penetration grade paving asphalt. The side slopes were reinforced with a 5 oz/sq yd cotton fabric. The compacted earth blanket was 5 ft thick at the top of the slope, 15 ft at the bottom, and 10 ft over the entire floor of the reservoir.

The Garvey Reservoir in Monterey Park, Calif., completed in 1954, is another example of a large, asphaltic-concrete–lined reservoir. It has a capacity of about 500 mil gal. An underlying, impermeable blanket of earth was constructed to make the reservoir water tight. A 3-in. porous asphaltic-concrete lining provides defense against erosion. A standard mechanical spreader was used on the reservoir slopes, which were 3:1. Cost of the lining was 14–15 cents per square foot on the bottom and 20 cents on the slopes.

Other notable examples of asphaltic-concrete–lined reservoirs in California are the Eagle Rock Reservoir and the Green Verdugo Reservoir, completed in 1953, the Upper Stone Canyon Reservoir, completed in 1954, Silver Lake Reservoir, whose sides were lined in 1954, and Lower Stone Canyon Reser-

voir, completed in 1956. All of these reservoirs utilize a 3-in. asphaltic-concrete lining on 2:1 and 3:1 slopes.

There are many small reservoirs which have an asphaltic-concrete lining, placed either with a spreader box, by timber screeds, or by simple hand raking.

Asphaltic concrete is also extensively used in lining both canals and flood channels. To accelerate this type of work various slip-form paving machines have been developed. The uncompacted asphaltic-concrete mix is fed into a hopper and spread and compacted by means of two adjustable screeds. The strike-off screed cuts off an even spread and the heated and loaded ironing screed compacts the mixture.

Prefabricated Lining

Prefabricated, flexible, molded asphalt linings are of two types. One type is designed to be covered with earth and gravel, as is the sprayed type of buried asphalt membrane. This type may be used for membrane seepage control when circumstances are unfavorable for use of the sprayed membrane.

The second—and most popular—type of prefabricated lining is constructed with asphalt-saturated asbestos roofing felt as a backing for a $\frac{1}{2}$-in. thickness of sand-asphalt filler mixture compacted on the asphalt-coated paper. The compacted mixture is composed of concrete sand, a fine dune sand, and diatomaceous earth. This type of lining is made in 4-ft widths and constructed in sheets of desired lengths, up to 25 ft. After being laid in place this lining is left exposed without any protective coating.

The prefabricated lining is extensively used for lining reservoirs and canals where seepage and erosion must be controlled. It is especially advantageous for use in small installations where hot asphalt cannot be handled in economical quantities or where hot-asphalt equipment or skilled labor, or both, are not conveniently available. Prefabricated linings do not require skilled labor to install and may be stored for future use, which simplifies maintenance problems. These factors are very important in many irrigation districts and in areas which have special need for water conservation.

The sheets of prefabricated lining are flexible but tough enough to be handled and to conform and maintain their shape on the contour of a subgrade or ditch line without rupturing. Field joints used with these linings are of two types: butt joints and lap joints. With the butt joint a reinforcement strip is placed over the joint to seal effectively and add strength to the joint. All joints are sealed with a mastic applied between layers of the lining.

Prefabricated linings will vary in cost from 25 to 60 cents per square foot, depending upon conditions. The recently completed 10-mil gal reservoir at Ramona, Calif., near San Diego, was lined with $\frac{1}{2}$ in. of prefabricated lining at a contract price of 30 cents per square foot.

Several other types of prefabricated asphalt linings have been tried in experimental projects. Burlap backing, cotton mat reinforcement, fiber glass reinforcement, and aluminum foil reinforcement have been used. An original development in this field utilized 90 lb of paper as a backing for a $\frac{3}{16}$-in. layer of catalytically blown asphalt. It was intended that the paper would serve during the manufacture, shipping, and handling of the lining.

When the paper disintegrated after the lining was in place, the asphalt would remain.

Other Hydraulic Uses

Experts are not always in agreement when designing earth fill and rock fill dams on whether it is preferable to construct an impervious layer on the upstream surface of the dam or to build an impervious screen in the core of the dam. With either method impervious construction is generally continued vertically in the subsoil in the form of a cutoff wall to the required depth. A slanting position for the impervious layer in the upstream part of the dam is sometimes chosen as an intermediate solution.

An impervious asphaltic-concrete layer on the upstream surface in conjunction with a cutoff wall at the upstream toe of a dam is comparatively easy to construct by methods similar to those described previously in this article in connection with reservoirs. Such a facing on a dam is easy to repair and maintain. It is flexible enough to avoid the cracking to which a rigid lining is often subject.

European countries have many examples of asphaltic-concrete–faced dams and revetments. Many leaks in concrete dams in Europe have been repaired with impervious asphaltic-concrete facings. Holland has a very notable history of asphaltic-concrete–faced revetments. In California a notable example of an asphaltic-concrete–faced dam is the Glen Anne Dam near Santa Barbara, completed in 1952, with a 12-in. impervious lining on the dam's upstream face.

Of interest to those connected with hydraulic planning and perhaps of great potential practical value is the experimental, low-cost sealing of a portion of the Friant-Kern Canal in the San Joaquin Valley in California. This was recently done with a catalytically blown asphalt. A catalytically blown asphalt is produced by blowing the asphalt by air in the presence of a catalyst which produces a very tough pliable membrane. The canal section chosen had a badly cracked, unreinforced-concrete lining through which excessive water loss took place. As a final protection the membrane was sprayed with an asphalt-base aluminum paint. The costs for this project were 28 cents per square yard for labor, equipment, and preparatory work and 51 cents for material, making the total cost per square yard 79 cents. It should be pointed out that the project was experimental and relatively small.

There are many other hydraulic uses of asphalt. For example, asphalt may be used for jetties, sea walls, and groins, and massive asphalt may be used for underwater protection and in the form of underwater blocks. Probably, however, these subjects would not be of much general interest to most water engineers and executives. Asphalt may also be used as a coating to protect pipe from corrosion or it may be used to reduce the maintenance required on access roads and parking areas at plant installations. These subjects, and others, although they are worthy of serious consideration, are too detailed to be discussed in this article.

it's too late when they start telling you!

AQUA NUCHAR

ACTIVATED CARBON FOR TASTE AND ODOR CONTROL

Here's the best way to avoid embarrassing taste and odor complaints. Stop them before they start . . . with daily threshold odor tests and AQUA NUCHAR!

AQUA NUCHAR activated carbon has high affinity for all substances that commonly taint water supplies. Properly applied in sufficient dosage, it efficiently adsorbs tastes and odors from algae, decaying vegetation, trade-wastes and other matter, soluble and insoluble. Concentrations required average as low as 2-5 ppm for extremely economical control.

We have produced activated carbon for industrial use for over 40 years, so when you use AQUA NUCHAR you benefit by our experienced technical assistance. And since stocks of AQUA NUCHAR are always readily available from 25 strategic warehouses, deliveries can usually be made within 12-24 hours.

We would be pleased to make a survey of your plant and to estimate your requirements.

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for your most vital service

Water . . . your community's most important single service . . . must be protected by sound financing. The only *sure* protection is the sustained accuracy of your water meters.

If a meter becomes inaccurate, it starts to give away revenue. In home after home, leaks and carelessness go scot-free. The warning voice of the meter is gradually stilled, and wanton waste soon uses up your available water supply.

Worse yet, lack of proper income makes it impossible to build new capacity without tremendous losses. Water shortages soon become critical. Your city's development program soon dies . . . of thirst.

How guard against this? Set up a good meter testing and repair program. Pick meters that stay accurate longer. Talk to your meter superintendent . . . the man whose efforts guard your water supply. Ask which brand of meter consistently gives highest sustained revenue . . . with lowest repair and depreciation. We sincerely believe your answer will be "Trident."

2818

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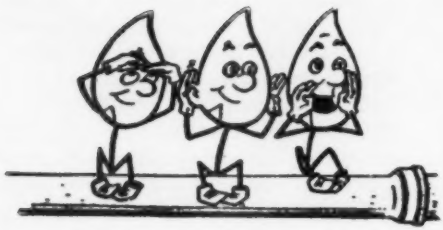


Percolation and Runoff

The Board wasn't bored, but it was belabored during almost all its waking hours between noon of Sunday, Jan. 25, when it convened at the Park-Sheraton Hotel in New York, and noon of Tuesday, Jan. 27, when it recessed until next July. The results of the belaboriousness are reported in the February and March issues of *Willing Water* and will be covered in more detail in the April JOURNAL, but some of the sidelights of the meeting have been neglected.

Brightest of these was Larry Daniel, director from the Cuban Section, whose obvious delight at being "a free man among free men again" was an inspiration to everyone. Larry's first-hand account of Cuba's rebirth enthralled a Sunday dinner assemblage of 100 officers, directors, past-presidents, and wives and, later, the 400 members at the Tuesday luncheon meeting of the New York Section. Reborn, too, he promised, will be AWWA's Cuban Section.

Tastiest of the sidelights were the basketball-size oranges supplied by the Florida Section and the Washington "Aplets," an apple-nut confection which brought greetings from the Pacific Northwest Section. And both tasty and thoughtful were the gifts which President Lew Finch brought along as examples of Indiana's integrated industry—Seagram's Seven Crown and Ancient Bottle to make the dinner enjoyable and Miles Laboratories' Alka Seltzer to promote postprandial productivity.

With such matters as certification, advancement, the new activities and objectives committee, and the impending secretarial switch (see p. 44 P&R) on the agenda in addition to the normal operations of the Association, there was scarcely time for Floridian Fred Eidsness' caucus of the southern directors on the issue of grits. By Monday night, however, the New York Section cocktail party, various dinner parties, and the best shows in town did find most of the brass knocking off for a while. And on Tuesday afternoon, with the job completed, almost all were on hand to relax at the New York Section luncheon, where Wendell LaDue, the featured speaker, pointed out, "The Future Is Always With Us."

All aboard for home by Wednesday, the Board will see another seaboard when it next convenes—on Jul. 12 in San Francisco. For that, not only all the Board, but all ought to be aboard.

(Continued on page 44 P&R)

(*Continued from page 43 P&R*)

The 'many a slip' fraught with most danger these days appears to be 'twixt the tap (rather than the cup) and the lip, and a tale that made this exceedingly clear is one from the *New England Journal of Medicine* reporting on the investigation of bedside water supplies in 24 Boston hospitals. A check of 103 bedside carafes by a team of physicians and bacteriologists disclosed the fact that the water in 22 per cent of them contained coliform organisms and the water in 69 per cent contained *Staphylococcus aureus,* including at least one of the deadly, penicillin-resistant strains. That the public water supply was not responsible for the contamination was quickly established, as was the fact that the hospital housekeeping techniques were at fault. Actually the investigators found that two-thirds of the carafes were "grossly unhygienic," resulting principally from the fact that they were difficult to clean and no proper cleaning tools were available, that they were made of materials that could not be sterilized by heat, and that no hospital specified disinfection as part of the cleaning routine.

Among the suggested corrective measures, bedside taps are not one, although they would probably be the

Raymond J. Faust receives congratulations from Secretary Harry E. Jordan after the Board selected Faust to succeed Jordan when the latter retires Sep. 1. Faust has been executive assistant secretary of AWWA since 1951.

(*Continued on page 46 P&R*)

EMINENCE IN EQUIPMENT DESIGN gives you *plus* values

IN INFILCO EQUIPMENT FOR WATER, SEWAGE AND WASTE TREATMENT

Here are examples of INFILCO PLUS VALUES...

More Production in Less Space...Compact designs, exemplified by the ACCELATOR® treating plants, save up to 80% of the space required by "conventional" methods.

Savings in Installed Cost...Because of minimum space requirements, many INFILCO units can be installed for much less, resulting in substantial savings in complete installation cost.

Low Maintenance...Rugged construction, elimination of underwater bearings, and custom design for each application result in long equipment life with very little downtime.

Chemical Savings...Recirculation and other techniques frequently reduce chemical consumption to the minimum laboratory requirements.

Reliability...Conservative design with liberal safety factors for peak demands afford full design capacity and trouble-free operation.

Proper Treatment...The experience of over 60 years assures you of the best for your requirements.

These and other important plus values are available from INFILCO—the world's leading manufacturer of water, sewage, and waste treating equipment.

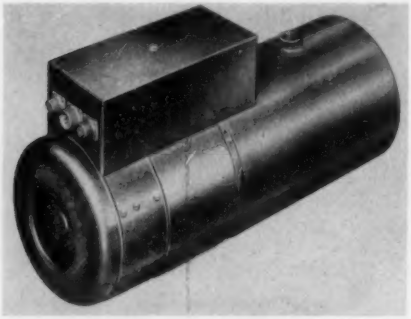
INFILCO

INFILCO INC. General offices—Tucson, Arizona
Field offices throughout the United States and in other countries.

(Continued from page 44 P&R)

most effective. Meanwhile, water works men are all in favor of the adoption of the recommendations for sterilization and handling of both carafes and ice-making equipment. Accustomed as they are to seeing their work go down the drain, they certainly don't want to see it "go down the drain" in this way.

A heater for water storage tanks that produces 60,000 Btu/hr with a maximum fuel rate of 0.75 gph is announced by the Mobile Products Dept. of Perfection Industries, 1135 Ivanhoe Rd., Cleveland 10, Ohio. Weighing 32 lb, the Model E-511 heater requires



1.2 cu ft of space for installation. Factory-assembled multiples of the E-511 are available to meet larger heat capacity requirements.

There's 'afford' in your future, it seems—a time when you'll not only be able to afford to supply your customers all the water they need when and where they need it, but when you'll not be able to afford not to. Just how far in the future that time is depends to a considerable extent on how successful the water supply industry is in convincing its customers that improved water service is possible and desirable and worth the price. Meanwhile, indications are that public appreciation, at least on the basic facts involved, is beginning to grow:

Consider the overwhelming approval that New Jersey's voters gave its water supply referendum last November, the fact that the new governor of California has been willing to propose a $500,000,000 bond issue for referendum in 1960, and the fact that the Kentucky legislature has been concerned enough about water supply to set up eight different fact-finding committees pointing to the development of 1960 legislation on such matters as water uses and needs, water quality, and the conservation of ground and surface supplies.

Consider the interest that prompted *Fortune* magazine to feature a special article on "The Worst Public Works Problem" in its December 1958 issue, and many other nontechnical publications to devote more and more space to coverage of the various aspects of the water problem.

Consider the factors that induce the investment house of M. B. Vick & Co. of Chicago to run the following newspaper advertisement:

Why Are Water Revenue Bonds Among YOUR BEST Investments?

1. *Because*—historical experience has shown water revenues are easier to collect than taxes. Penalty for nonpayment is discontinuance of service.

2. *Because*—water is a necessity and even in the hardest times water consumption falls very slightly.

3. *Because*—water systems become more vital to a community as population increases.

(Continued on page 48 P&R)

the problem...

Problem: Move 30,000 gallons of sea water per minute through aggressive soil and ground water.

The Project: Magnesium-oxide plant for Michigan Chemical Company at Port St. Joe, Fla.

The Engineer: Cunningham-Limp Company, Detroit, Mich.

The Solution: 36″ diameter Cen-Vi-Ro Water Pipe made with sulphate resisting Portland Cement and limestone aggregate; two inches of concrete cover for the reinforcing steel; six inches of loose oyster shell all around the pipe.

The Result: Service life estimated at more than 50 years.

Cen-Vi-Ro Pipe . . . engineered and made to your specifications . . . serves you better. When your job calls for concrete pipe, call Concrete Pipe Division, Vulcan Materials Company, Atlanta, Georgia.

CONCRETE PIPE DIVISION

VULCAN MATERIALS COMPANY

P.O. Box 6226, Station H, Atlanta, Georgia • JAckson 4-6244

(*Continued from page 46 P&R*)

4. *Because*—water works systems are "decreasing cost" public utilities. As the number of people using water increases, the cost per user will decrease.

5. *Because*—municipal water plants have no competition.

6. *Because*—it is mandatory (by statute and ordinance) to maintain adequate rates at all times, to set aside periodically in special accounts adequate funds to cover both interest and principal payments, maintain and operate the system, and accumulate a specified percentage for depreciation.

7. *Because*—in most states municipal utilities' rates may be raised when necessary on short notice by the municipality.

8. *Because*—experience has shown that the incidence of default of high grade water revenue bonds has been extremely rare.

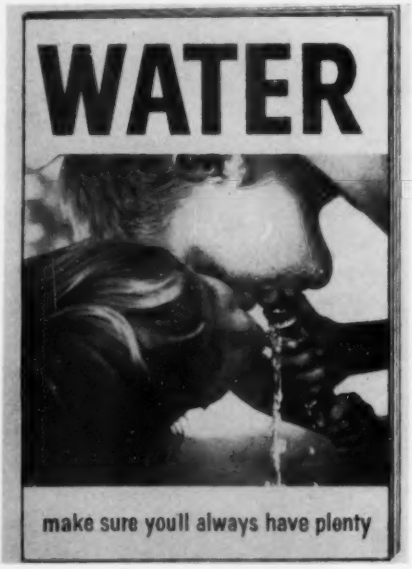
9. *Because*—water revenue bonds are purchased for investment by most of the insurance companies, estates, and investors.

10. *Because*—a water system is self-supporting and the debt self-liquidating.

The municipal water works revenue bond, in its legal and economic aspect, is the most certainly secured investment. Interest is exempt from all present federal income taxes. Wouldn't water revenue bonds be an advantageous addition to your portfolio?

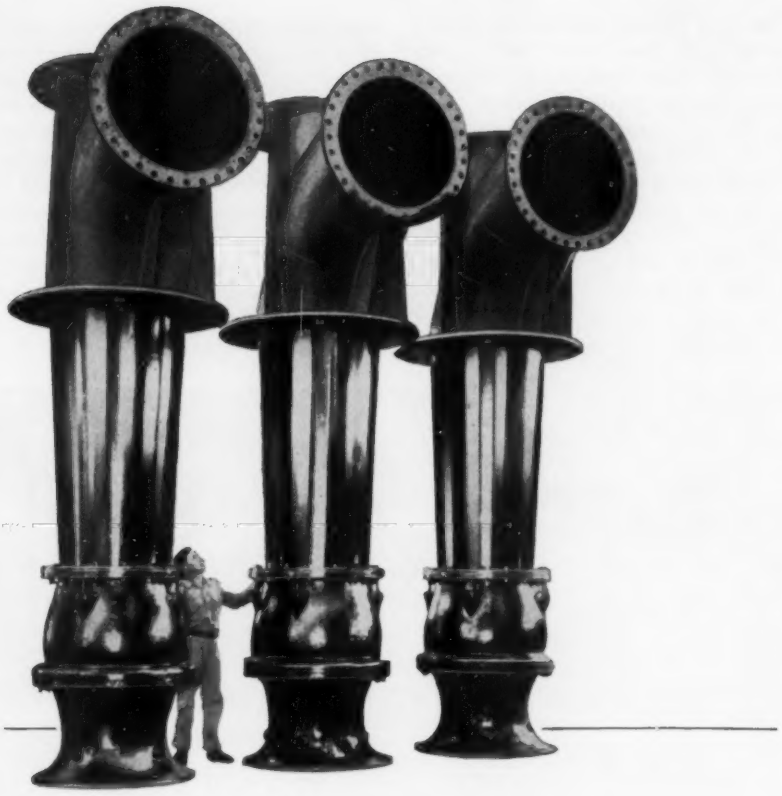
All these are indications of a growing public awareness of water supply —an awareness that constitutes the first step in selling the public. But the public must still be *sold* on the fact that improved water service is worth what it costs. The AWWA Advancement Program is aimed at doing that. The Water & Sewage Works Manufacturers Assn. Public Relations Program is aimed at doing that. But the man who must close the sale is the local water utility manager. Him we can caution: Don't let "afford" go by!

Speaking of selling water service, the Cast Iron Pipe Research Assn. has just embarked on a new nationwide program to help do just that—and incidentally, of course, to sell some pipe as well. Kicking off the program were two children with a water hose in an advertisement in the February issue of *Readers Digest*, through which CIPRA offered a free booklet, entitled "WATER—make sure you'll always



have plenty" (see cut) telling citizens how to determine the status of their own community water systems and how to help their water utility managers toward "improved water service." Not forgetting the manager either, CIPRA, through its member companies, is making available to him a "Community Relations Portfolio," that tells him how to help citizens to help him. The telling is selling, and we hope the selling will be telling.

(*Continued on page 50 P&R*)



the bigger your pumping problems

. . . the better your reasons for

giving them to

WHEELER-ECONOMY

You know how big problems can be, in selecting pumps for water works reservoir service. The Pumps you see here are specially designed and built to solve such problems. They're 36" Axial Flow Wheeler-Economy Pumps, each of which delivers 28,000 gpm. And they've been in continuous service for many years with only routine maintenance and modest operating costs.

If you're puzzled over which pumps to use for water works, municipal or industrial power plant service, drainage, irrigation or flood control, see C. H. Wheeler. Your representative can help you even if you need capacities exceeding 220,000 gpm and heads of 75 feet. He'll give you expert advice on pump design and construction, and station arrangement suggestions you'll find helpful.

Economy Pump Division

C. H. WHEELER MFG. CO.

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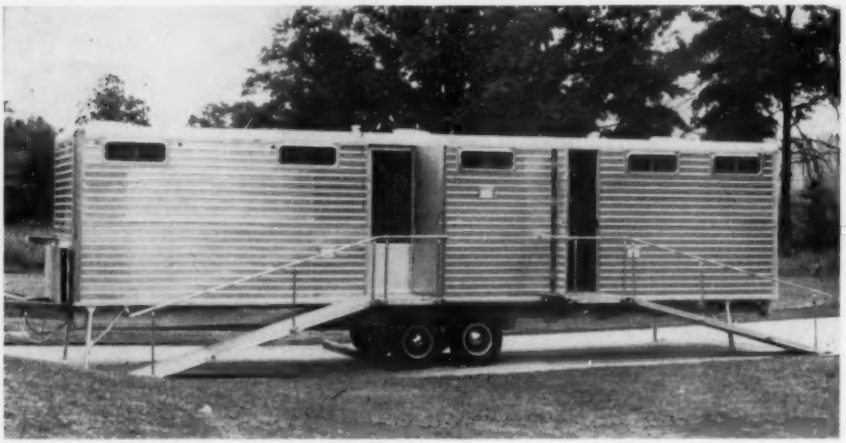
Whenever you see the name C. H. Wheeler on a product, you know it's a quality product

Centrifugal, Axial and Mixed Flow Pumps • Steam Condensers • Steam Jet Vacuum Equipment • Marine Auxiliary Machinery • Nuclear Products

(*Continued from page 48 P&R*)

Not just selling, but merchandising is something that water utility men could well learn, too, as a means of getting through to the customer. And what better organization to help them than the Fred S. Gichner Iron Works of Washington, D.C., which has just now started production of the first all-aluminum WC on wheels. What the Good Humor Man did for ice cream, this new mobile comfort station certainly ought to be able to do for water (and perhaps even sewage). Just think of it—a sleek, shiny, 36-ft trailer unit (see cut), with fluorescent lighting and high windows to illuminate the interior, a 550-gal water supply, and separate three-piece folding ramps for men and women, purveying not just water, but *comfort* to the public—all the comfort it needs, when and where it needs it!

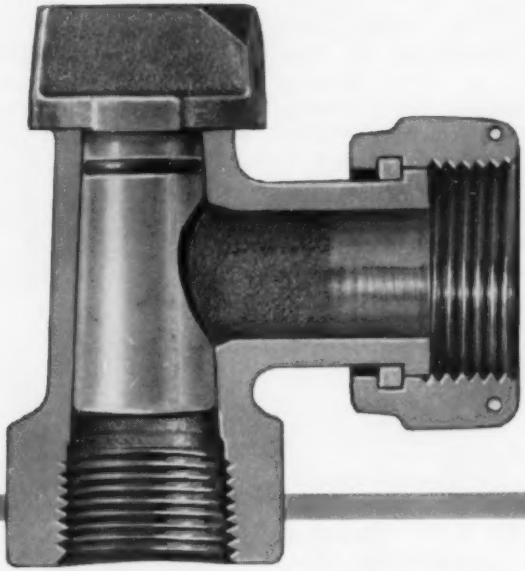


Even admitting to a concern or two over how—not to mention why—550 gal is to be stretched to "accommodate" 600 individuals, as the Gichner literature indicates, we have already multiplied the accommodatees by the current comfort rate of 10 cents per accommodation and determined that the $60, even less the considerable maintenance and capital costs, ought to leave us a good bit more than the normal 15 cents for the amount of water provided. Why, with a fleet of traveling toidies operating on regular routes and a few on hand for emergencies, the rate problem might soon become a matter of secondary interest.

We can see one coming down Main Street now with bold lettering: "FEEL QUEASY, GO EASY!" Hometown Water Department. Or, harking back to an old, though certainly not overused, slogan, DO IT NOW!

J. V. Kyle has been appointed president of the Concrete Pipe Div. of Vulcan Materials Co. He was formerly executive vice-president of the division, which operates eight plants in Georgia, Alabama, and Florida, with headquarters at Atlanta.

(*Continued on page 52 P&R*)



New "O" ring seal positively prevents leakage ...in all **MUELLER**® *Angle Meter Stops*

Now, all Mueller Angle Meter Stops are produced with an "O" ring seal at the top of the key. This new "O" ring, plus a generous ground key surface between the port and the top of the body, gives a dependable, positive double seal against leakage which may be caused by piping stresses on the stop body.

This improved design is typical of the intense attention to detail in research, design and engineering that becomes a part of every Mueller product produced for the water industry.

MUELLER CO. **DECATUR, ILL.**

Factories at: Decatur, Chattanooga, Los Angeles; In Canada: Mueller, Limited, Sarnia, Ontario.

(*Continued from page 50 P&R*)

A hot one, indeed, was the story of the warming well on Chalmer Lovdahl's farm at Monmouth, Ill. (see February P&R, p. 48). Having brought the Lovdahls fame, crowds, and correspondence galore by producing continually warmer water until it reached a temperature of 110°F after 4 months, the 36-year-old well finally yielded its secret after intensive investigation by experts of the State Water Survey. To get to the bottom of things, Survey engineers drained the well and checked temperatures as it refilled, then checked a series of soil borings in the vicinity, thereby eliminating, in turn, such suggested possibilities as an incipient volcano, a coal vein fire, and a hot uranium deposit, and settling instead on a leaking hot-water pipe as the cause. The pipe, which ran from a water heater in the pump shed to the house, came close to the well, soil around the pipe was tightly packed, the escaping hot water found a channel into the well—presto, a cooker.

Now Chalmer's a farmer once again, his ten children don't have to be on their best behavior any more with all the company gone, his wife can get a good drink of water without refrigerating it, and catastrophe no longer impends. All of which may be to say that things are not so hot any more.

A stinker, meanwhile, was the source of news from another part of the world—from Stinkenbrunn (stinking well, that is), Austria. As of the first of the year the community changed its name to Brunn. The newspaper account, which noted:

> Stinkenbrunn dates back to the 13th century. A local well's waters had a bad odor and a sour taste from nearby lignite deposits. Now the coal is gone and the water is pure.

inspired one Russell Johnson of the Michigan Health Dept. to verse:

> Der Brunn was gestinken,
> Die people not fond of der pun;
> Now der coal ist removen,
> Die Burgers approvin'
> No linkin' of Stinken mit Brunn.

All we can say is: Well!—Brunn, that is!

The water works safety conference held on the University of Illinois campus at Urbana, Ill., Jan. 28–29 was pronounced highly successful by the 73 water utility managers who attended, as well as by the sponsors—the university's Dept. of Civil Engineering and the State Dept. of Health's Div. of Sanitary Engineering. It is intended to hold a similar conference annually.

(*Continued on page 54 P&R*)

MONTEREY SAND CO.

Crystal Amber Filter Sand & Gravel

"The Standard of the Industry"

In conformity with A.W.W.A. specifications for filtering material or made to your own specification.

Shipped Bulk or in 100 lb. bags.

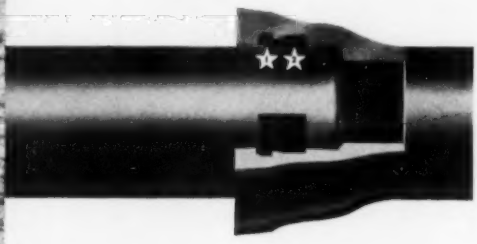
Filtration specialists for over 15 years

P. O. Box 928, Monterey, Calif. — Inquiries Invited

★ Fast Installation

★ Adequate Deflection

★ Leak Free



AMERICAN Fastite ★★ JOINT CAST IRON PIPE

The immediate nation-wide acceptance given American Fastite Joint pipe—introduced just two years ago—is proof of its outstanding quality. Already, several *millions* of feet are now in service.

Ease and speed of installation—with only one joint component, a double-sealing, dual-hardness rubber gasket—means economy from the start. Its deflection capability means additional economy.

Combined with the proven longer service life of high strength cast iron, the American Fastite Joint offers many special advantages for water, sewage and other liquid service.

Get full facts from your nearby American Cast Iron Pipe Company representative while your project is in the planning stage. Ask him about Fastite—American Fastite Joint cast iron pipe.

AMERICAN CAST IRON PIPE CO.
BIRMINGHAM ALABAMA

SALES OFFICES
New York City • Dallas
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San Francisco • Denver
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Faster LOCATING!
LOWER SERVICE COSTS
with the improved AQUA VALVE BOX LOCATOR!

Your Name In Gold FREE!
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STOCK this useful tool for every service CAR and CALL •
Speed Locating • Keep Customers Happy

- NO WIRES, BATTERIES or SWITCHES—simple, powerful magnetic action, factory adjusted to YOUR geographical location assures unfailing results!
- NO NEEDLE SPINNING—exclusive electric braking action saves you time!
- NO STOOPING—easy top-view reading!
- RUGGED—compact, accurate, convenient!
- GUARANTEED—to function regardless of weather, surface or ground cover!
- NATION'S MOST WIDELY USED LOCATOR!
- 15-DAY FREE TRIAL—No money! No obligation! You be the judge!

ORDER NOW - Wire or Call Klrby 1-4200 collect

AQUA SURVEY & INSTRUMENT CO.
2028 Leslie Ave., Cincinnati 12, Ohio

FIND LEAKS FASTER
WITH THE AQUA SURVEY AQUAPHONE

Only $4.50 EACH
6 for $25.00
ORDER NOW

RUGGED! SENSITIVE!
Super-sensitive scientific pre-tuned diaphragm without mechanical connection between diaphragm and probe, makes this the industry's most durable instrument. Genuine molded Bakelite case. Unconditionally guaranteed against mechanical failure for life of instrument! Order one for every service man. 2 Ft. probe Extension $2.25.

AQUA SURVEY & INSTRUMENT CO.
2028 Leslie Avenue Cincinnati 12, Ohio

(*Continued from page 52 P&R*)

A dam nuisance ever since October 1944 has been interfering with the operation of the sluice gates at Sorpe Dam near Arnsberg, Germany, and a 12,000-lb nuisance it turned out to be when the reservoir was drained last month to make repairs to the gates—*it* being an unexploded British "tallboy" bomb stuck in the mud. Now, all that needs to be done before repairs can get under way is to defuse the bomb and pull it out. Elected for the task was an RAF flight lieutenant, appropriately named Waters, who is a veteran of 1,370 defusals in the past 5 years. Bombs aweigh, we say, and long live "Willing" Waters.

Philadelphia Suburban Water Co., which supplies approximately 600,000 persons, has been purchased from the Clarence H. Geist estate by a three-man syndicate, including Thomas W. Moses, president of Indianapolis Water Co.; James H. Clark, an associate of Clinton W. Murchison; and Wentworth P. Johnson, senior vice-president of Fidelity-Philadelphia Trust Co. A price estimated at more than $18,000,000 was paid for about 550,000 of the 790,000 shares outstanding.

December 17 was the day when the Navy almost had another brain knocked out, this time a lot closer to home than Pearl Harbor—in the Philadelphia Navy Yard. Fortunately firemen were able to put protective covers over it before water, leaking from a 20,000-gal rooftop tank that had cracked with the cold, seriously affected the yard's $2,000,000 electronic brain. Time was when water on the brain was an individual problem. Then it was a question of who could think; now, who needs to?

(*Continued on page 58 P&R*)

FIRST OF TWO ELEVATED WATER TANKS FOR JOLIET, ILL.

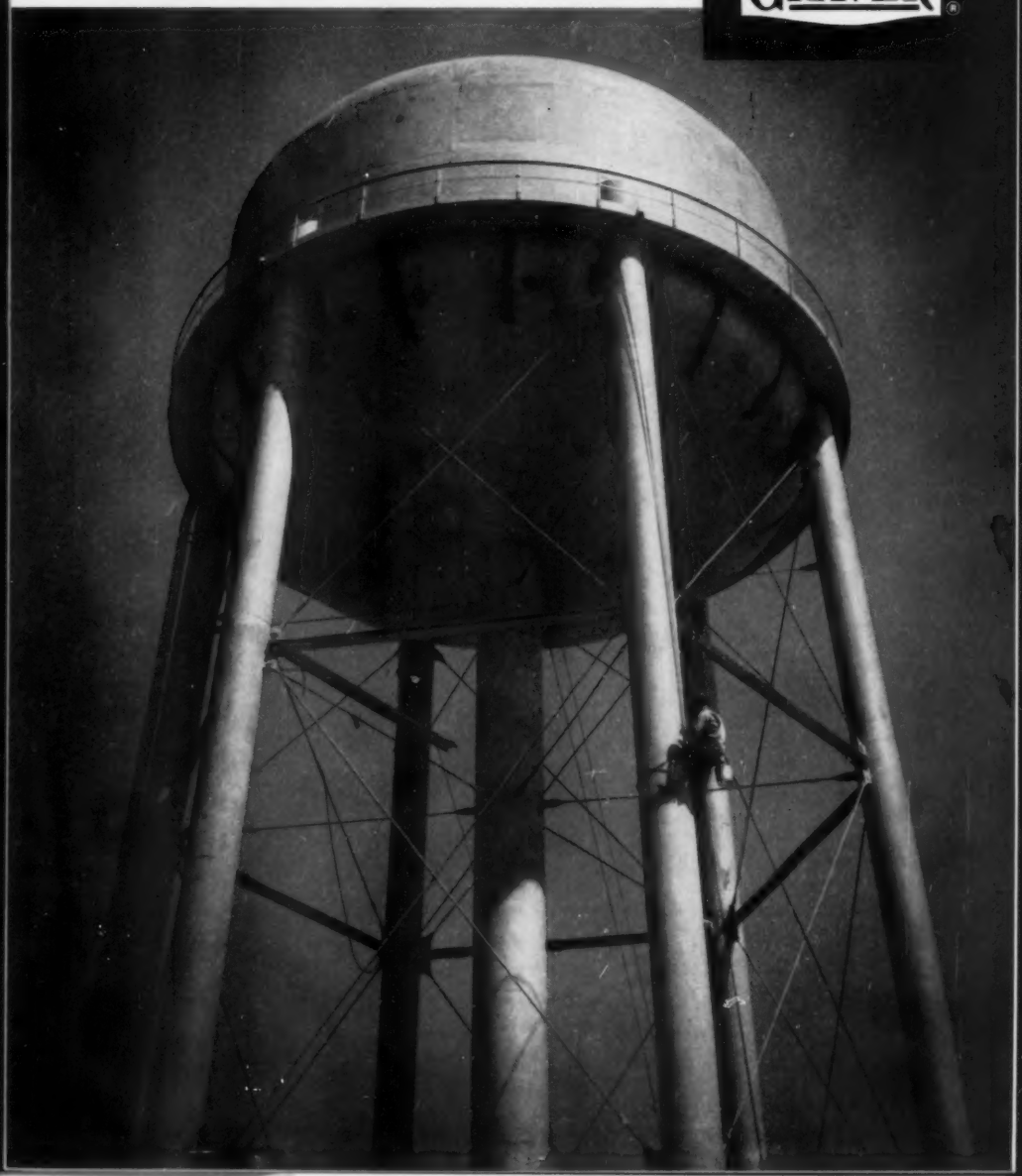
A 7.4 million dollar water modernization and enlargement program started in 1947 will soon be completed in Joliet, Ill. This is another step forward in the growth of this thriving Midwest industrial community, which won the coveted All-American City Award several years ago. Two elevated water tanks, including the 250,000 gallon tank below, were designed, fabricated and erected by Graver.

GRAVER TANK & MFG. CO. EAST CHICAGO, INDIANA

DIVISION—UNION TANK CAR COMPANY

Plants and Offices Across America

GRAVER®

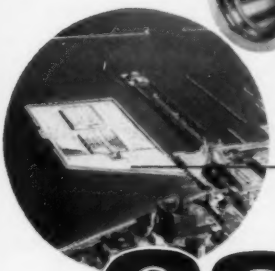


CLOW

Start of installation of Clow cast iron pipe with intermediate Bell-Tite joints in one of 192 half filter beds which compose the filter underdrain system. The Bell-Tite flare tees are first set in concrete. Note Chicago skyline in distance.

Installation of pipe and tees partially completed. Clow Bell-Tite joints permit easy and rapid assembly—an important factor especially in a job of this magnitude. Bell-Tite forms a pressure-tight joint instantly. Photo shows Neil Sullivan, pipe foreman for George D. Hardin, contractor (right), and Lewis C. Alk, Manager, Clow Technical Service Department.

CAST IRON PIPE



In Chicago's huge filtration plant—

62 MILES OF CLOW CAST IRON PIPE

in filter underdrain system

Chicago's new Central District Filtration Plant, now under construction, will be the largest in the world. Located on a 61-acre tract of filled-in land on Chicago's lake front, it will have a normal capacity of 960 million gallons of water a day—a maximum capacity of 1680 million gallons a day. The plant was designed by Department of Public Works, City of Chicago, Bureau of Engineering, Filtration Design Division.

Over 62 miles of Clow 4" cast iron pipe—27,264 runs of pipe with 13,632 Bell-Tite® and flare tees compose the underdrain system for 192 half filter beds. Each pipe length is supplied with perforated holes with brass eyelets and has a cast iron plate welded in one end. Each Bell-Tite tee has two eyelet holes.

Easy, rapid assembly permitted by the Clow Bell-Tite joint contributes greatly to economical installation.

OUR 81ST YEAR • 1878 TO 1959

JAMES B. CLOW & SONS, INC.
201-299 North Talman Avenue, Chicago 80, Illinois

Subsidiaries:
Eddy Valve Company, Waterford, N.Y.
Iowa Valve Company, Oskaloosa, Iowa

CLOW CAST IRON PIPE

(*Continued from page 54 P&R*)

More competition for water utilities has apparently developed on two fronts of late—in cooling for industry and in fluoridation. In the cooling field, *Chemical and Engineering News* last Dec. 22 reported, many industries are finding that air can cool more cheaply than water—"even, sometimes, when water is cheap and abundant." Standard Oil Co. (Ohio), Esso Research and Engineering Co., and Celanese Corp. all report economically advantageous switches to air cooling, and when water is in short supply, of course, the advantage accumulates. Meanwhile, in the fluoridation field, a family of pharmacists in Mendham, N.J., has established a new business marketing prescription fluoride drops in special bottles with droppers marked to measure out the proper dosage per child per day in the area served. The product, trademarked under the name "Les-Cav," is sold only on doctor's prescription, but it is making available a substitute method of protecting children's teeth where water fluoridation programs cannot gain approval.

To both these sources of business some water works men will probably say good riddance, but we wonder. . . .

Hazen & Sawyer, consulting engineers, New York and Detroit, announce that the following have been made associates in the firm: Francis P. Coughlan Jr., John W. Neave, Remig A. Papp, Joseph N. Rizzi Jr., Walter B. Sinnott, and C. Richard Walter.

(*Continued on page 60 P&R*)

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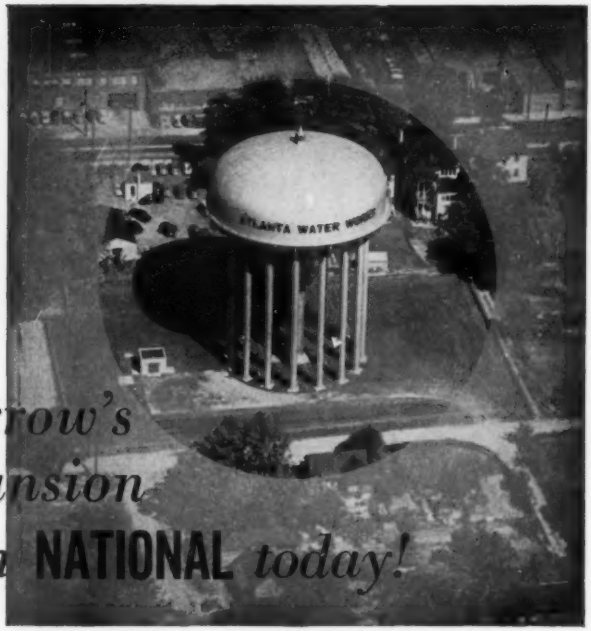

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(Continued from page 58 P&R)

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has bought the York, Pa., firm of S. Morgan Smith Co., manufacturer of valves, pumps, and turbines. Purchase of the Smith holdings, largely family owned, was on an exchange-of-stock basis. The new acquisition will operate as the Hydraulic Div. of Allis-Chalmers, with headquarters at York, thus increasing to five the number of divisions in A-C's Industries Group, which produces a broad line of generating and transmission equipment and industrial machinery. Beauchamp E. Smith, president of S. Morgan Smith prior to the purchase, has been named vice-president and general manager of the new division.

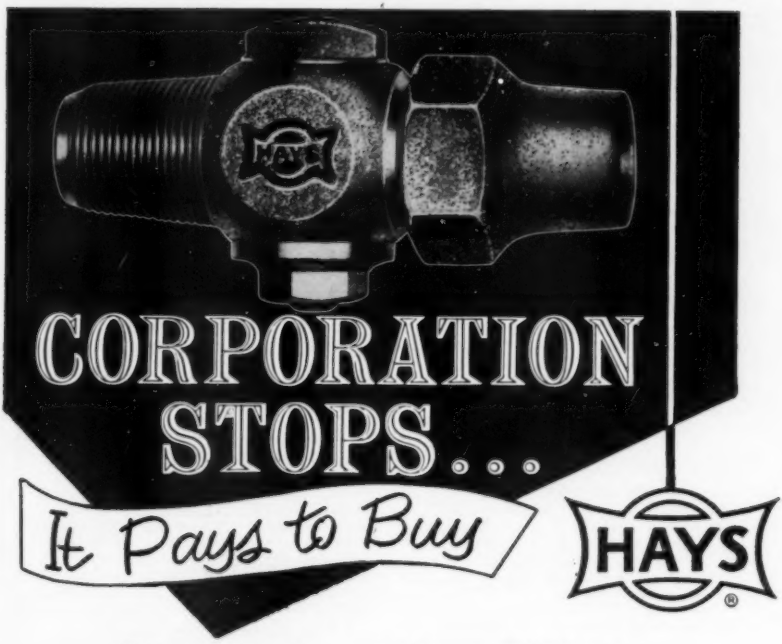
E. Robert Baumann, professor of sanitary engineering in the Dept. of Civil Engineering at Iowa State College, Ames, has been granted a 1-year Science Faculty Fellowship by the National Sanitation Foundation, beginning Sep. 1, 1959. He plans to do postdoctoral study in biochemistry and bacteriology at an English university.

Dorr-Oliver Inc. has moved all its filtration engineering and development operations from Oakland, Calif., to its headquarters at Stamford, Conn., in order to centralize the engineering and manufacture of filtration equipment in the East and provide improved service to customers.

Fisher Research Lab., manufacturer of pipe finders, leak detectors, and other electronic equipment, has completed an extensive program of

One of the two S. Morgan Smith Co. plants at York, Pa., now being operated by the Hydraulic Div. of Allis-Chalmers (see story above).

(Continued on page 94 P&R)



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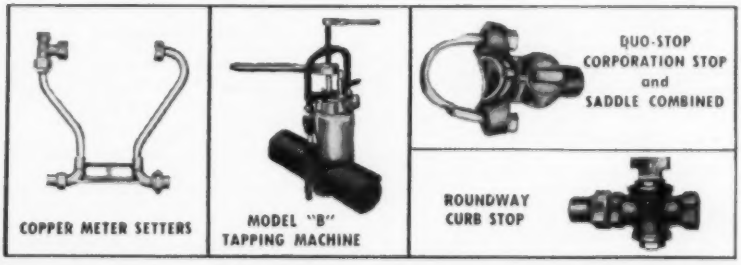

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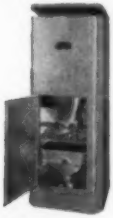

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

INDUSTRIAL WATER USE

Is American Industry Dying of Thirst? Mill and Factory, **60**:5:81 ('57). By '75, further industrial expansion in US may be prevented by severe water shortage resulting from increased industrial and domestic water consumption and requirement for water of higher purity for industrial purposes. Situation may be improved by increased utilization of existing water supplies, by thorough water surveys, by recharging existing wells, by treating waste water, by installing water meters on internal lines to check on wastage, by helping to build natural reservoirs, and by forming industry-community groups to conserve water. Brief mention is also made of common methods of water treatment.—*WPA*

The Influence of Discharge Water From Chemical Industries on the Water Supply System. A. V. KANYGINA & I. D. RODZILLER. Vodosnabzhenie i Sanit. Tekh. (Moscow), No. 4: 25 ('57). Detns. were made, for both summer and winter, of highest concns. of several org. and inorg. compds. which could be present in river water without harming organisms. Harmless concns. were: KCl, 500 mg/l in summer and 2,750 in winter; NaCl, 500 and 1,250; Cl^-, 20 and 30; $(NH_4)_2CO_3$, 39; sulfates, 140; Fe, 0.6 in summer and 0.9 in winter. $(NH_4)_2SO_4$ increases development of water flora. Fe salts are toxic in ionized form but not in colloidal form. Types and effects of org. compds. are discussed. Methods to prevent contamn. are suggested.—*CA*

Water Utilization and Treatment Efficiency of Gulf Coast Cooling Towers. NATIONAL ASSOCIATION OF CORROSION ENGINEERS. Corrosion, **13**:527t ('57). Data submitted by 16 oil refineries and chem. plants on Gulf Coast on utilization and treatment of water for cooling towers have been evaluated. It appeared that avg. plant was properly utilizing quant. of water required for removal of sensible heat but that, in general, cooling towers were operating well below optimum eff.—*WPA*

Supporting Data Relating to the Determination of Ammonia in Industrial Water and Industrial Waste Water. Proc. ASTM, **56**:355 ('56). At low ammonia concns. (0.1 mg NH_3 as N_2 per 500 ml at pH 7.4), 99% recovery was obtained where 300 ml of distillate was collected and aliquot nesslerized, as compared to 75% acctd. for in 4 separate 50-ml portions of distillate. Hydrolysis of glycerol and glutamic acid on distn. at pH 7.4 and greater was negligible. Acetamide did not hydrolyze at pH 7.4 but underwent increasing hydrolysis with subsequent increase in pH. Urea hydrolyzed to give 7.7% recoverable ammonia at pH 7.4, increasing to 17% at pH 14.0. No hydrolysis was found for two org. N rust inhibitors, octadecylamine and cyclohexylamine, at any pH value (7.4, 9.0, 11.0, and 14.0) used, but these compds. are distillable and produce turbidity in nesslerized sample. Even at concns. in which they are used in practice turbidity was obtained in 1st 50-ml portions distd.—*CA*

The Cooling-Water Operation Cycle, Its Operation as to Practicability and Economy. R. HOFFMANN-SCHIFFNER. Wasserwirtsch.-Wassertech. (Berlin), **7**:436 ('57). Problem of industrial water supply is considered and economical use of water is emphasized. Principle of recirculation of water in industry is described. It consists of const. circulation in specially designed equip. It operates as cooling medium, warming itself during application in given process and flowing in closed system as recooling system. Use of water with and without recirculating principle from '47 thru '54 is compared graphically. It was clearly shown that

(*Continued on page 72 P&R*)

New Coagulant Cuts Costs of Water Treatment

Fast Action Permits High Flow Rates

High speed coagulant action of Nalco 614 is especially good news for the many municipal water treating plants now operating over rated capacity. In fact, the extremely fast action of this new coagulant promises better operating efficiency in *any* municipal system.

Characteristics of Nalco 614

Basically, Nalco 614 is a new sodium aluminate coagulant. It has excellent dry feeding characteristics due to a new manufacturing process that produces near spherical granules. It is a fast dissolving, highly soluble material.

Rapid coagulating action boosts equipment capacities, virtually eliminates post-precipitation.

Nalco 614 is being used alone, with lime and soda ash, and with low dosages of common coagulants such as alum or activated silica.

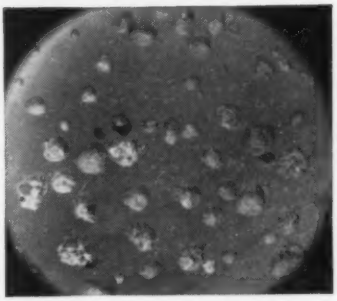
In softening systems, Nalco 614 improves hardness reduction, as well as coagulation. Since it is an alkaline material, lime and soda ash dosages can be reduced.

Plant Reports

There is no substitute for full-scale use of a new product to prove its usefulness and advantages. Here are some of the results that water works report after putting Nalco 614 to work:

"Saved almost $1,000 per Month over the cost of previous treatment, principally alum," says one filtration plant superintendent.

Replaced Alum and Ferric Sulfate at a municipal water plant in Iowa. This plant softens water to 85 ppm. Previous cost of alum, iron, lime and soda ash was $239.00 per day. Replaced 25 parts alum and 50 parts ferric sulfate with only 8 parts Nalco 614. Lime and soda ash dosages also reduced because of 614 alkalinity. Cut overall chemical cost to $150.00 per day; a saving of $89.00 per day — $32,485.00 per year!



Photomicrograph of Nalco 614 particles shows one of the reasons for its excellent handling and dry feeding characteristics: spherical grains that assure free flow through conventional dry feeders.

1 ppm 614 Outperformed 10 ppm Alum according to the experience in a California municipal plant: "Nalco 614 is doing a beautiful job of both coagulation and feeding."

Quotes on Nalco 614 Handling

Here are some typical comments on Nalco 614 handling characteristics:

"I have never seen any material which fed as well and as uniformly as Nalco 614."

"Nalco 614 flows easily, requiring no agitation and no banging on the outside of the hopper."

"It feeds as easy as rice alum. We have been able to whip all of the feeding problems that have plagued us..."

Action for Your Plant

Nalco 614 has a record of results in municipal water treating that comes close to the spectacular . . . and there is no reason why it cannot perform the same way for you. Call your Nalco Representative, or write Nalco direct for prompt action toward Nalco 614 savings and performance in your plant.

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Nalco CHEMICALS

(*Continued from page 70 P&R*)

operation of recirculation system for cooling used considerably less water during '50–'54. Costs are also analyzed for 2 processes.—*CA*

Coolant Technology in a Pressurized Water Reactor. P. COHEN. Proc. Ann. Water Conf., Engrs. Soc. West. Pa., 17th Ann. Conf., 45 ('56). Pressurized water reactor used in elec. power industry is described and flow diagram of cooling system is given. Problems in operation of reactor are caused by reactions between coolant and its containers, between coolant and fuel, and by creation of radioactive elements by neutron capture of corrosion products and plant material and by fission of fuel material. Austerite stainless steels or carbon steels are used for constr. of coolant containers since stainless steel is resistant to corrosion in alk. water, and carbon steel, although corroding more rapidly, is immune to stress corrosion cracking which affects stainless steel in presence of chloride. Chem. reactions induced in water by irradiation are described. It has been found that finely divided magnetite, corrosion product, is deposited on fuel elements during irradiation. Expts. showed that increasing pH value of cooling water to 9.5 prevented deposition, which was observed to be greatest when oxygen concn. of water was higher than usual. In attempt to det. effect of deposits on operation of reactor density, thermal cond. and fluid friction of deposits were calcd. Treatment of radioactive corrosion products, radiochemistry of cooling water, and prevention of release of fission products from uranium oxide fuel elements are discussed. Decontamn. and disposal of radioactive waste waters are described.—*WPA*

Effecting General Cost Reductions and Controlling Industrial Wastes Problems by Water Management. K. S. WATSON. Proc. Ind. Waste Conf., 11th Conf., No. 91:478 ('56). Increasing demands for water for industrial and municipal purposes make it necessary for industry to adopt integrated water management policy. This should include selecting site of new plants to obtain best source of water from point of view of quant., qual., and cost; softening and conditioning water where necessary for special plant uses; conserving water and reusing it wherever possible; reducing vol. of waste waters as much as possible; and providing adequate treatment of waste waters before dischg. Such policy can result in considerable saving in costs, in addn. to reducing both water requirements and vol. of waste waters. Examples of measures taken at some plants of General Elec. Co. are cited.—*WPA*

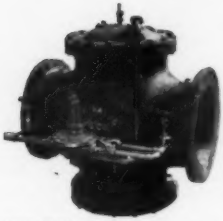
Industry and the Public Services. A Survey in Valley of River Tees (Br.). Surveyor (London), **116**:747 ('57). Vast developments are in progress in steel, coal, and chem. industries in area around Tees R. (Br.) but public services, including water supply, are completely out of balance with great industrial developments. Rate at which new water resources are being developed is not high enough to satisfy ever-increasing demands. Chem. industry requires vast quants. of water, I.C.I. works at Wilton alone requiring 250 mgd of cooling water from river; in addn. to phenomenal demands of chem. industry are needs of great steel plants and industries and appreciable domestic demand which must expand as housing development proceeds. Major problem facing Tees Valley Water Board at present is that industry is depleting service reservoirs faster than they can be filled and suitable sites for new reservoirs are difficult to find. By '60 it is expected that supplies will be available from new 2,900 mil gal Selset impounding res., now under constr. in Lunedale. This will have safe yield of about 16 mgd and should ease situation but will not solve problem. Another impounding res. is planned in Upper Teesdale and should be in use by '63.—*WPA*

Water Treatment for Monochrome Television Picture Tube Manufacture. E. E. CHASE. Proc. Ann. Water Conf., Engrs. Soc. West. Pa., 17th Ann. Conf., 147 ('56). Processes in mfr. of television tubes, which require demineralized water, are described briefly. Water must have low concn. of org. matter and salts which would contam. phosphor coating or form gas when tube is in use must be elimd. At plants of Television Picture Tube Div. of Sylvania Elec. Products, Inc., 2 water treatment systems are used, 1 consisting of sand filter, activated-carbon filter, 2-bed demineralizer, aerator, and mixed-bed unit, and other consisting of retention tank in which water is treated with alum, sand and activated-carbon filters, and mixed-bed demineralizer.

(*Continued on page 74 P&R*)

1879—ROSS—1879

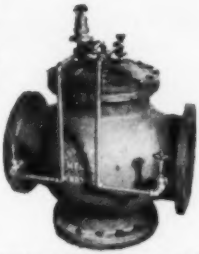
Automatic Valves



ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting



SURGE-RELIEF VALVE

Maintains safe operating pressures for conduits, distribution and pump discharge

REDUCING VALVE

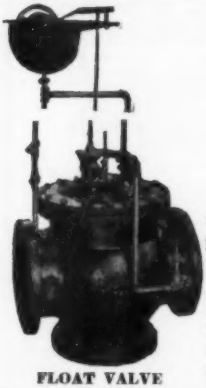
Maintains desired discharge pressure regardless of change in rate of flow

Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

COMBINATION VALVE

A self contained unit with three or more automatic controls

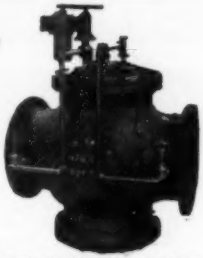
Combination automatic control both directions through the valve.



FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.



REMOTE CONTROL VALVE

Electric remote control—solenoid or motor can be furnished

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

Packing Replacements for all Ross Valves Through Top of Valve

ROSS VALVE MFG. CO., INC., P. O. BOX 593, TROY, N. Y.

(*Continued from page 72 P&R*)

Prelim. treatment of water is necessary to prevent fouling of ion-exchange resins and to remove org. matter which affects screening process. When surface waters were used as source of water chlorination was necessary to prevent algal growths in filter beds. Control of the temp. of demineralized water is described. Advantages of mixed-bed and multibed demineralizers are compared and effect of reduction of surface tension on suitability of surface waters for television tube mfr. is considered.—*WPA*

AQUATIC ORGANISMS

Unusual Phosphorus Source for Plankton Algae. W. ABBOTT. Ecology, **38**:152 ('57). Tests were made to find source of phosphorus used by planktonic algae in L. Houston, new impounding res. in Tex. Chem. anals. of plankton and noncolloidal detritus from lake were made but no phosphorus was detected in samples. It was observed that runoff from watershed following rains produced high load of colloidal clay particles in water. Samples were taken: half were filtered and half still contained colloidal material before being analyzed for phosphorus. Samples contg. colloidal matter contained avg. of 85 μg/l phosphorus in phosphate equiv. form, and filtered samples contained only minute quants. It was therefore deduced that planktonic algae were deriving their nutritive phosphorus from complex polyphosphates or organic phosphorus compds. without aid of dissolved phosphate equiv. intermediate stage. Further research is being carried out on this.—*WPA*

The Eradication of *Asellus aquaticus* From Water Supply Mains. G. J. HOLLAND. J. Inst. Water Engrs. (London), **10**:221 ('56). Detailed acct. is given of investigation of possible methods of eradicating *Asellus aquaticus* from water supply mains in Coventry (Br.) following increasing consumer complaints of its presence. It was shown that *Asellus* did not enter water supply system from either ground or surface

(*Continued on page 76 P&R*)

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Sodium Silicofluoride – 99%
(Powder)

Sodium Fluoride – 98%
(Powder or Granular)

Meet AWWA specifications

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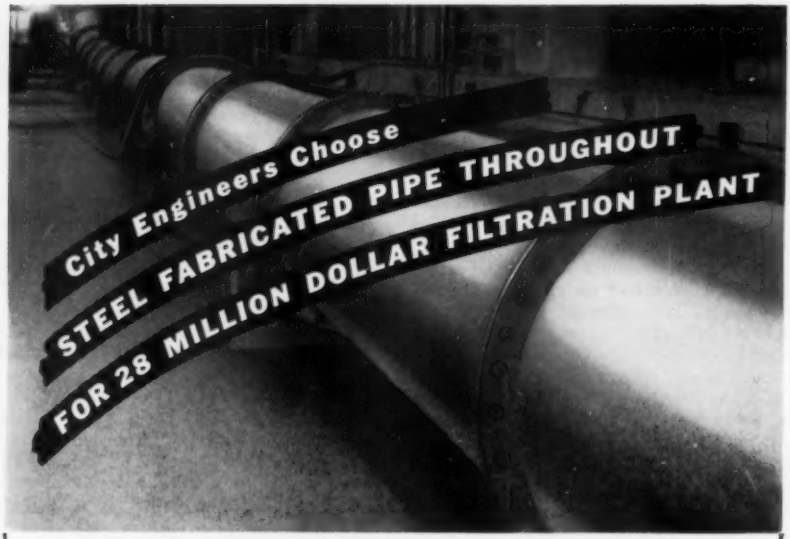
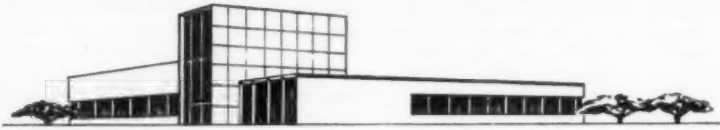


Morgan Keeps Installation Costs to a Minimum in Complicated Multi-level Operation!



When the city of Cleveland began planning its magnificent new $28,000,000 filtration plant, it realized that it faced a complicated engineering problem that could well run out of hand in cost.

A mile from Lake Erie's shore, water will flow through its intake, travel underground at a depth of 123 feet and enter the building to be chemically treated by a series of settling basins and filters. In the process, passage is through a maze of 42" Steel Pipe, Fabricated by Morgan, lined with coal-tar enamel that curves around chamber walls, descends and ascends from floor to floor; at times traveling at foot level, then rising to ceiling height. When completed, the plant will convey pure water to supply part of Cleveland's west section . . . at a rate of 50 M/G every 24 hours, with an ultimate expansion to 140 M/G every 24 hours, again using Steel Pipe, Fabricated by Morgan.

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(*Continued from page 74 P&R*)

sources of supply nor at treatment plants, and it is thought crustaceans gained access to distr. system via mains damaged as result of air raids during WW II. Life history of species is outlined. Lab. expts. carried out to exam. factors influencing normal metabolism and reproduction and effects of toxic substances on *Asellus* are described. Results showed that most practicable method of eradication was chlorination to suppress reproduction. Accordingly 1 zone of distr. system, which traps of mains revealed presence of very large nos. of *Asellus* among which reproduction was taking place, was treated by addn. of chlorine and ammonia at treatment works. Treatment was carried out in '52 from Apr. to Sep., which is reproduction season, and chlorine-ammonia concn. in water leaving treatment works was increased gradually from 0.1 to 0.8 ppm, maintd. at 0.8 ppm for 3 mo., and decreased again to 0.1 ppm. Treatment, as revealed by *Asellus* collected in traps, not only suppressed reproduction but by its effect on iron bacteria limited food available in mains and caused mortality of *Asellus*. Chlorine-ammonia treatment was extended to other zones of distr. system and was repeated during summer months in '53, '54, and '55, resulting in eradiction of *Asellus aquaticus*.—*WPA*

Ammonification of Organic Nitrogenous Substances in Water and Bottom of Sevan Lake. M. E. GAMBARYAN. Doklady Akad. Nauk Armyan. S.S.R. (USSR), **23**:183 ('56). In L. Sevan in Armenian S.S.R. pop. of ammonifying bacteria is highest in spring of yr. In bottom sediments highest pop. is found in silts and lowest in sands. Bacteria which mineralize org. nitrogen compds. are most numerous in latter half of yr. Thus, mineralization of proteins occurs continuously in lake.—*WPA*

The Conditions for the Fixation of Free Nitrogen in the Lakes of the Latvian S.S.R. II. The Fixation Conditions for Free Nitrogen in the Bottom Deposits. F. PERA. Latvijas PSR Zinatnu Akad. Vestis (Riga), **7**:93 ('57). In these investigations fixation of N was always detd. together with deg. and kind of mineralization of bottom deposits—that is, tot. org. matter (**I**) and Ca always were detd. Presence and development of *Azotobacter* bacteria were closely connected to amts. of **I** and of Ca in these deposits. At lake bottoms naturally low in **I**, occurrence of *Azotobacter* was linked closely to presence of sufficient Ca. If both amts. of **I** and Ca were increased *Azotobacter* would grow better, but there was upper limit to such growth. If more **I** was added beyond this point, especially **I** which had reducing action, growth of *Azotobacter* would be impaired, irrespective of amt. of Ca present. Only high dose of Ca could counteract such damaging action. pH of 7 or weakly alk. H_2O was favorable for development of *Azotobacter*. Large excess of **I** counteracted favorable effect of pH. All these lake bottoms contain enough assimilable P to sustain growth of *Azotobacter* bacteria. If lake bottoms become acid or too cold for prolonged periods of time viability of bacteria is preserved. All lake deposits also contained bacteria of genus *Clostridium*. *Azotobacter* are biochemically just as active on lake bottoms as in soils, but *Clostridia* are never as active as *Azotobacter*.—*CA*

Nutrition and Metabolism of Marine Bacteria. II. Observations on the Relation of Sea Water to the Growth of Marine Bacteria. R. A. MACLEOD & E. ONOFREY. J. Bacteriol., **71**:661 ('56). In continuation of studies on nutritional requirements of marine bacteria it was found that need of 6 marine bacteria for sea water in chemically defined medium was due to ability of sea water to supply inorg. ions necessary for growth. No evidence was obtained that sea water was capable of supplying unknown org. factors either required by or stimulatory for growth of these organisms. Rate and extent of growth of all organisms tested were increased by addn. of supplementary iron to medium. None of organisms grew unless sodium and potassium were added. Addn. of magnesium was necessary for 4 of organisms and stimulated growth of other 2. 1 organism required presence of calcium, and early growth of another was stimulated by it. There was no signif. growth of any of organisms in absence of phosphate, and absence of sulfate inhibited growth of 4 organisms and reduced amt. of growth of other 2. 1 organism required chloride and growth of another was limited by its absence; remainder were either unaffected by its absence or needed chloride for optimum rate of growth. Attempts to acclimatize 2 of organisms to grow in complex medium prepared with fresh water failed.—*WPA*

(*Continued on page 78 P&R*)

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WATER PURIFICATION EQUIPMENT
STANDARD OF QUALITY FOR MORE THAN 60 YEARS

WATER FILTRATION PLANTS and EQUIPMENT
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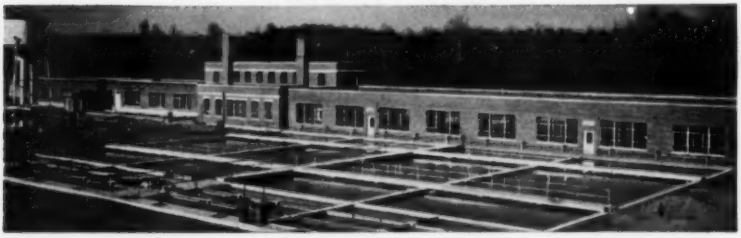

This 8 million gallon a day water treatment plant is typical of the many hundreds of Roberts-equipped installations throughout the United States, Canada and Latin America. We welcome the opportunity to cooperate with engineers on all types of water filtration equipment projects.

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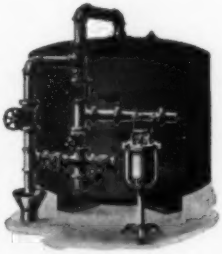

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This modern pool at Levittown, Pa., built by Levitt and Sons, Inc., is representative of the thousands of Roberts-equipped swimming pools. We produce a complete line of swimming pool recirculating plants and filtration equipment, backed by more than 60 years experience in the field of water purification.

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For every rugged industrial pumping job there's a specific FloWay available to do it better. Superior materials . . . precision manufacturing . . rigid inspection . . thorough design . . each is a reason why FloWay vertical turbine pumps are setting new performance standards in industry. For assured *dependability*, inquire today for the FloWay you need—backed by two generations of experience.

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Choice of standard cast iron or fabricated steel heads. Replacement parts readily accessible from world-wide local sources.

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(*Continued from page 76 P&R*)

Second Progress Report on Aquatic Life Water-Quality Criteria. Ohio River Valley. Sew. & Ind. Wastes, **28**:679 ('56). 1st report included criteria for suitability of aquatic life environment. 2nd report presents recommendations on phys. conditions. Temp. requirements have certain range for each species. Changes affect both fish and other living organisms. Extent to which temp. of waters under study can be altered without killing fish has now been detd. Table shows limits for many fresh-water fish. Not only temp. increase but also its duration is important because habitat of fish is affected. Fish will move in temp. gradients, and hence will avoid stream of heated waste discharge within reason. Dissolved solids requirements are met in most natural waters, but productivity decreases with departure from optimum. Some fish can tolerate wide changes, such as going from salt water to fresh water and others have narrow range of tolerance. Settleable solids requirements concern both org. and inorg. material. Some fish require completely clear water, whereas others will thrive in muddy water, partly because their food supply thrives there. Direct effect of turbidity by suspendsoids is not important criterion. Wastes that form sludge beds or change phys. nature of bottom are most to be feared. Chloride ion requirements concern food, toxicity, and osmotic effect. These apply both to fish and its food supply. Although chloride ion in itself has little practical signif. accompanying cations are potentially toxic. Fluoride requirements are important because of its wide range in natural waters. Little information is available on its effect on fish. Fluoride should not be permitted at levels higher than found safe for humans. Color requirements are important because sunlight is needed by aquatic life. At least 25% of tot. solar radiation should reach plants. Current literature on DO requirements is analyzed. 5 ppm for 16 hr of any 24-hr period is best est. of correct value. Papers were analyzed with comparison of conditions to those existing in Ohio R. Valley. About 2–4 times as much oxygen is required by fish when active than when quiescent. Fish may adjust to low oxygen concns. within limits, particularly "coarse" fish, but such adaptation should not be counted on to establish acceptable oxygen levels. Studies provide valuable information.—*PHEA*

(*Continued on page 82 P&R*)

THROUGH THE YEARS

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CALMET'S all-bronze, split-case features, coupled with the exclusive frost-proof bolt, protect CALMET'S precision-built mechanism from freeze damage . . . insure constant accuracy. When you combine this with extremely low maintenance costs, you can readily see why to standardize on CALMET is to increase revenue.

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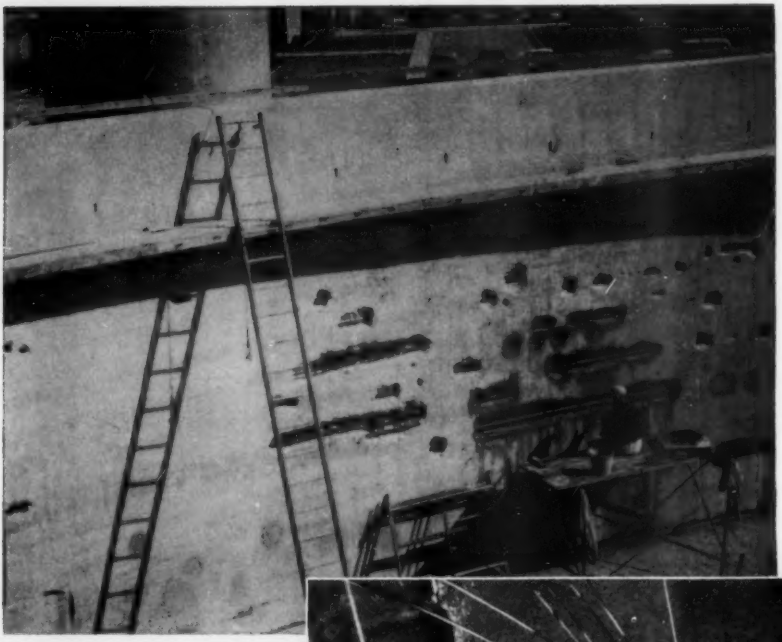
CONCRETE NEEDS CORROSION



Damage caused by sub-surface corrosion of steel reinforcing rods is shown in this view of tank interior.

Close-up of pre-stressed tank exterior shows large sections of gunite which were forced from wall by corroding wires.

PROTECTION, TOO

Case history of sub-surface corrosion shows porosity of concrete

When the Koppers Contract Coating Department was called in by an East Coast chemical processing firm for its recommendations on waterproofing sea-water treatment tanks, it found the conditions shown on the facing page.

Some tanks, up to 200′ in diameter, were formed of 16″-thick reinforced concrete. Although various coating systems had been tried in attempts to stop water migration, the concrete was spalled away in many areas by sub-surface corrosion of reinforcing steel.

Other tanks of the pre-stressed type at this same location were also attacked by corrosion in less than two years. Pre-stressed wires around the tank had failed due to corrosion caused by water migration through the walls and from the outside, through as much as a 1″ protective layer of gunite.

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(*Continued from page 78 P&R*)

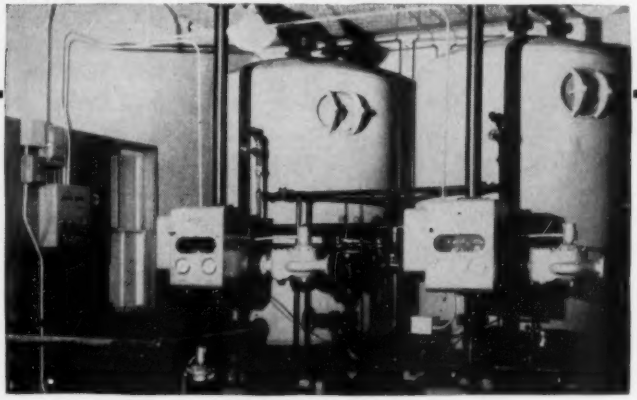
Nitrogen-Fixing *Spirilla* in Water. A. G. RODINA. Mikrobiologiya (Moscow), **25**:145 ('56). New *Spirilum, S. azotocolligens,* has been found in water supplies of Krasnodar Dist. (USSR). It fixes atmospheric nitrogen and shows normal cell forms only in non-nitrogenous media.—*WPA*

Strontium and Barium in Sea Water and Marine Organisms. H. J. M. BOWEN. J. Marine Biol. Assoc. United Kingdom (London), **35**:451 ('56). Strontium and barium cont. were detd. in sea water, marine algae, molluscan shells, and both recent and fossil corals. For sea water concn. of Sr was 8.5 mg/l and of Ba 6.2 μg/l. All organisms studied concd. these elements from sea water, but whereas brown algae discriminated markedly for them in preference to calcium, molluscans discriminated against them. Approximate linear relationship between Ca:Sr ratio and geological age from Devonian period suggested that Sr is accumulated in sea water.—*PHEA*

Environmental Factors Affecting Distribution of Mayfly Nymphs in Douglas Lake, Michigan. F. E. LYMAN. Ecology, **37**:568 ('56). Study of mayfly pop. of Douglas L., Mich., has shown that principal factors affecting distr. of nymphs are phys. character of bottom, light intensity, and wave action. Temp. and DO concn. have little, if any, effect on distr. of nymphs in lake, but *Hexagenia* nymphs are limited by oxygen concn. to that portion of mud bottom above level of hypolimnion.—*WPA*

Bioassay of Nitrogen Available to Two Species of Phytoplankton in an Offshore Water. H. W. HARVEY. J. Marine Biol. Assoc. United Kingdom (London), **36**:157 ('57). Results are given of bioassay of nitrogen available to 2 species of phytoplankton with their associated bacteria in offshore water. Concns. found by assay (11.5 and 13 μg nitrogen/l) were similar to concn. of tot. inorg. nitrogen compds. found by anal. (10 μg nitrogen/l). It appears that

(*Continued on page 84 P&R*)



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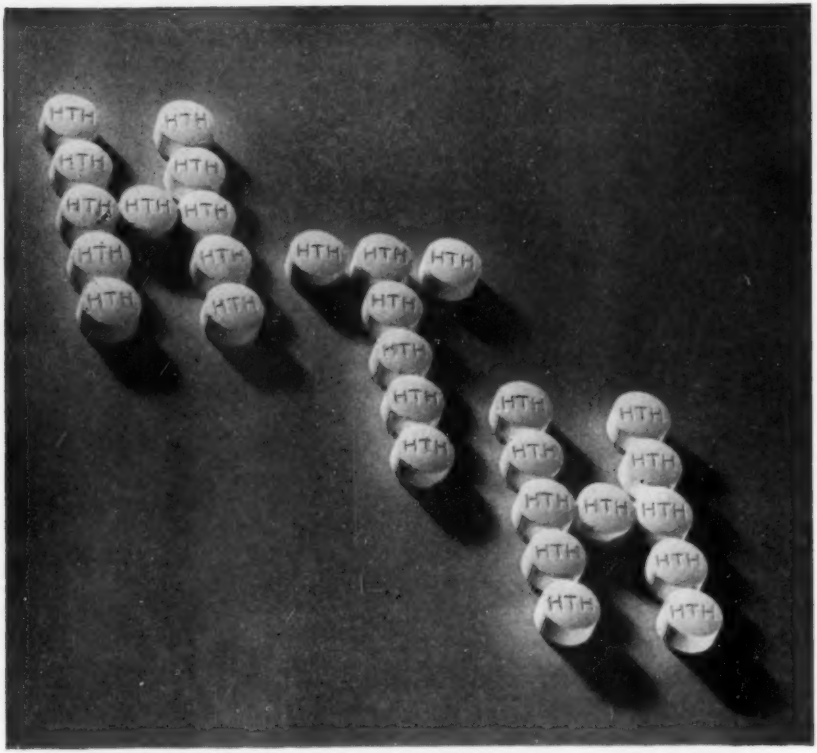

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(Continued from page 82 P&R)

only insignif. quant. of org. nitrogen normally present in soln. in sea water is available to plant-bacteria community.—*WPA*

Chemical Factors Limiting Growth of Phytoplankton in Lake Victoria. G. R. FISH. E. African Agr. J. (Kenya), **21**:152 ('56). Since '49 studies have been made on productivity of phytoplankton in L. Victoria. Observations of shallow bays and inlets showed that no annual cycle of phytoplankton occurred. Because climatic conditions in this area are favorable to growth it was thought that deficiencies in dissolved chem. nutrients might be limiting factors. Growth of *Chlorella* and *Anabaena* in lake water enriched with different inorg. salts was studied and it was found that omission of sulfate, phosphate, or nitrate from enriched medium had marked effect. Deficiency in sulfate appears to be most important limiting factor in L. Victoria because during certain periods phosphate and ammonia have been found in detectable concns. in lake water but no sulfate has ever been detected. Vol. of water flowing into lake is small compared with vol. of lake and supply of sulfate from these sources is likely to be of minor importance. Bottom deposits, after drying, were found to contain comparatively high concns. of sulfate (0.25 mg/g), but expts. have failed to show that any considerable quant. is released to water under natural conditions.—*WPA*

Quantitative Distribution and the Biomass of Microorganisms in the Oxygen Zone of the Black Sea. M. N. LEBEDEVA. Doklady Akad. Nauk S.S.S.R. (Moscow), **115**: 186 ('57). Numerical data on distr. of biomass of microorganisms and phytoplankton are tabulated and shown on map of Black Sea in various seasons for O depth zone. Highest concns. are found in near-Dniester R. (USSR) area and in northern corner of NW Black Sea. Microorganisms make up some 25% of tot. living matter in this sea, and microorganisms in oxygen zone amt. to 0.25% of phytoplankton biomass.—*CA*

Evidence for a Photosynthetic Daily Periodicity. M. S. DOTY & M. OGURI. Limnol. & Oceanogr., **2**:37 ('57). Variation of about 5.7-fold between photosynthetic ability of phytoplankton collected at sea in eastern, tropical Pacific waters between 8

(Continued on page 86 P&R)

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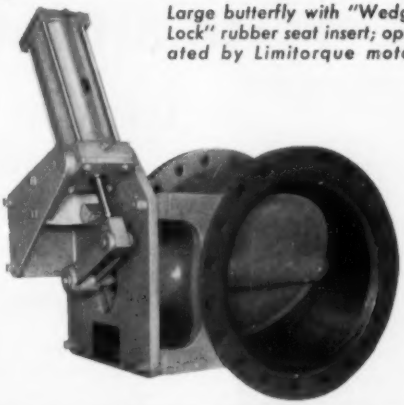
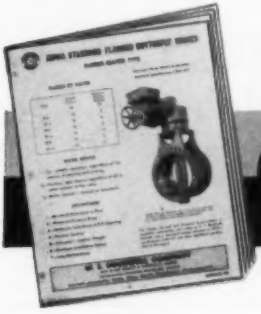


Butterfly valve with spool rubber liner; hydraulically operated.



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(*Continued from page 84 P&R*)

AM and 7 PM was observed, using carbon-14, light-dark bottle technique. This suggests that there is daily periodicity in photosynthetic ability of phytoplankton. It is thought that there will be rather rapid drop in photosynthetic ability near sundown and gradual increase thereafter to max. during day. It is not yet known whether there are corresponding variations in oxygen consumption or chlorophyll cont.—*WPA*

Indices of Productivity in British Columbia Lakes. T. G. NORTHCOTE & P. A. LARKING. J. Fisheries Research Board Can. (Ottawa), **13**:515 ('56). Relation between phys. and chem. indexes of productivity and std. crops of plankton, bottom fauna, and fish in 100 lakes in B.C. was investigated. There was found to be signif. increase in nos. of plankton and fish with increase in concn. of dissolved solids. It is suggested that similar relation exists for bottom fauna. General form of relation between mean depth and plankton and between bottom fauna and fish suggests hyperbolic curve with larger quants. in lakes of low mean depth, but only generalization which can be justified is that nos. of fauna from lakes of great mean depth was never as great as those found in some lakes of low mean depth. No signif. relation was found between intensity and length of growing season and nos. of plankton, bottom fauna, or fish, but there was signif. relation between summer temp. in epilimnion and nos. of plankton. Most important factor affecting productivity in all lakes studied appeared to be concn. of tot. dissolved solids in water, although within region neither tot. dissolved solids nor mean depth could be used, either singly or together, to predict nos. of plankton, bottom fauna, or fish.—*WPA*

***Pseudomonas tuticorinensis* Nov. Sp., A Marine Denitrifying Bacterium.** A. SREENIVASAN & R. VENKATARAMAN. Current Sci. (India), **25**:294 ('56). Bacterium capable of reducing nitrate has been isolated from marine sand off Tuticorin (India). Morphology and cultural characteristics of or-

(*Continued on page 88 P&R*)

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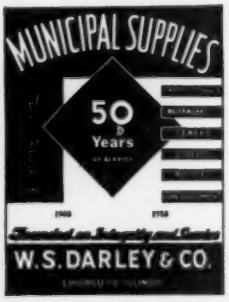
(*Continued from page 86 P&R*)

ganism are described. It differs from any previously described bacterium and has been named *Pseudomonas tuticorinensis* nov. sp. —*WPA*

The Distribution of *Neomysis americana* in the Estuary of the Delaware River. E. M. HULBURT. Limnol. & Oceanogr., 2:1 ('57). Distr. of planktonic shrimp *Neomysis americana* in estuary of Delaware R. was studied for 2 yr, in relation to circulation in estuary. It was found that *Neomysis* was more abundant in deep water of estuary than in surface or shallow waters, and was more abundant in estuary than in coastal waters at mouth of Delaware Bay. Shrimp increased in size from seaward end of estuary up to river end. It therefore appears that shrimp become older during their drift up estuary and tend to accumulate in estuary because of their avoidance of outflowing surface layers. No organisms were observed upstream of salinity limit of 4/1,000, and their absence from surface layers is attributed to their avoidance of light.—*WPA*

Living Organisms in Public Water Mains. K. M. HART. J. Inst. Munic. Engrs., **83**: 324 ('57). Occurrences of *Nais* and *Asellus aquatius* in public water supply systems are described and treatments discussed. *Cyclops* and *Daphnia* are eliminated by remedial action taken for destruction of *Nais*, nematodes, and *Asellus*. *Nais* infestation was elimd. by pumping soln. of 100 ppm Cl directly into branch mains, with consumer outlets closed, until high residual Cl could be read at extremity of branch. Whole section was then allowed to rest for 30 min and then was thoroughly flushed out until normal residual readings were again obtained at outlet. *Asellus*, on which Cl had little or no effect, was elimd. by feeding 2% pyrethrum soln. into trunk main to give 0.01-ppm avg. concn. (this dosage is not critical and is effective from 0.1 to 0.0001 ppm). No interruption of normal service was necessary as this level of pyrethrum is not injurious to humans. Treatment poisons *Asellus* sufficiently to make it relinquish its tenacious hold so it can be flushed out.—*CA*



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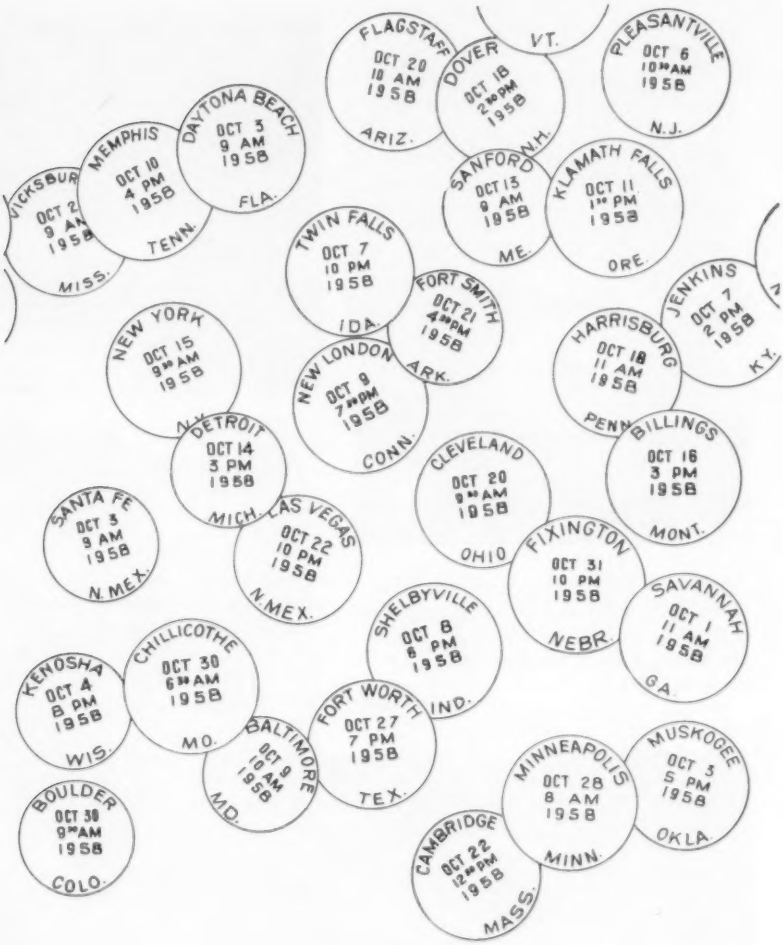
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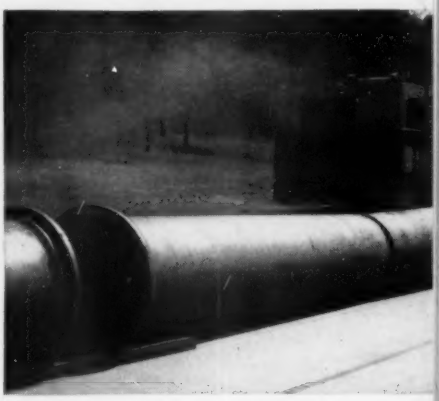

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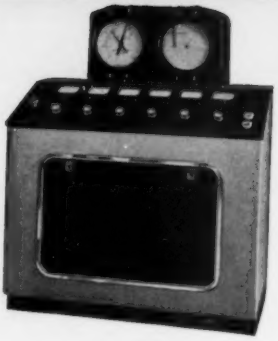

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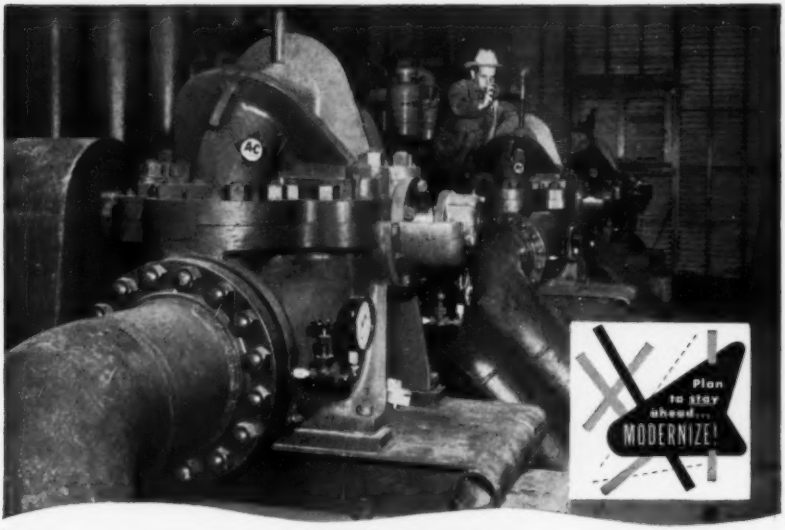

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(*Continued from page 60 P&R*)

construction and modernization at its existing plant location in Palo Alto, Calif. Research and development facilities have been doubled in space.

Muddy water is being drunk to and for, but not, quite yet, of. It won't be long now, though, as liquor revenues are paying for the installation of the municipal water system in the village of Muddy, Ill. From the ridiculous, the sublime.

Edward J. Clark, chief engineer of water supply, New York City Dept. of Water Supply, Gas & Electricity, has received an award for the best paper presented before the Society of Municipal Engineers of the City of New York during the year.

John E. Morrill, executive secretary of the Sewerage & Water Board, New Orleans, was given a surprise party by friends, coworkers, and city officials to celebrate his 50 years of service with the board, the last twelve as secretary. To mark the occasion, he was presented with a gold watch and a 50-year lapel pin.

The Holey City is what Hyderabad, India, will soon be called if authorities do not shortly find a way to stop the theft of manhole covers. A recent count disclosed almost 3,000 of them missing—apparently stolen for sale as scrap or to other cities. If you have a suggestion, Hyderabad boys say, do drop in!

(*Continued on page 96 P&R*)

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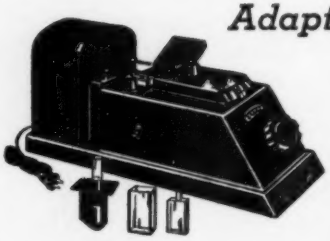

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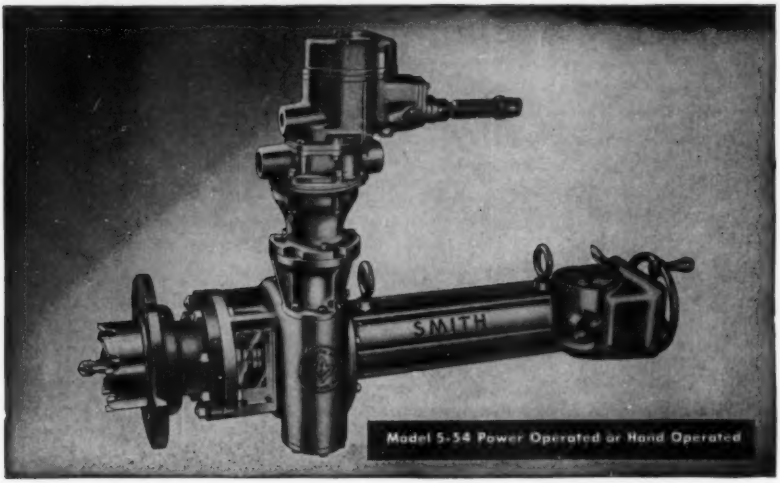

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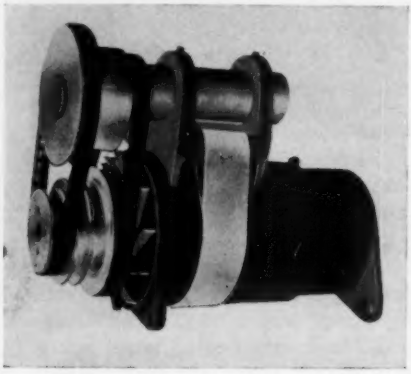
(Continued from page 94 P&R)

A generator overdrive system to insure peak generator performance and constant battery charge for all types of automotive vehicles, even at curb idle and with all accessories operating simultaneously, is being marketed by Consolidated General Products, Box 7425, Houston 8, Tex. The "Gen-O-Drive" unit works by instantly increasing generator rotation when the engine is idling or running at low speed; as engine speed increases, the generator is automatically returned to normal operating rate. The device is said to be easily installed and to require no periodic servicing.



Allan Kilpatrick, former superintendent of filtration at Montreal, Que., died Nov. 2, 1958, at the age of 73. Born in 1885 in Ottawa, Ont., he was employed in the construction of several hydroelectric power developments in the United States and in western Canada before entering the Public Works Dept. of Montreal in 1913 as chief inspector for the construction of the city's filtration plant. Upon the completion of the original 50-mgd plant in 1918, he became superintendent of filtration, a position he filled with distinction until his retirement in 1955. During this long period of service, he was responsible for the maintenance and operation of all electrical, mechanical, hydraulic, and other equipment required to produce, under variable conditions, a dependable and adequate supply of treated water for the rapidly growing needs of Greater Montreal. He was untiring in his efforts to maintain the plant in a high state of efficiency and to operate it economically.

Mr. Kilpatrick, a member of AWWA since 1948, was a recipient of the Canadian Section's William George Hunt Award, in recognition of his sincerity, reliability, and efficiency in the discharge of his duties as a water works operator.

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Positions Available

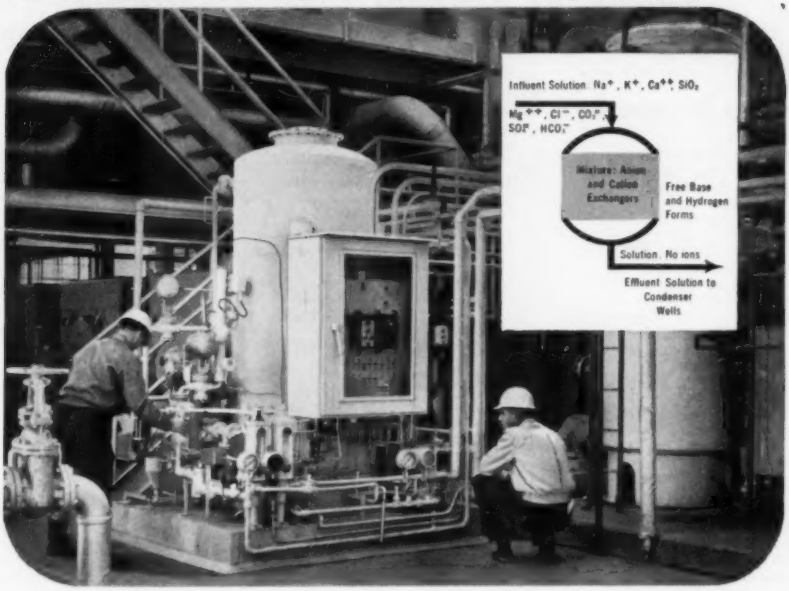
GENERAL MANAGER

for a Water and Sewer Department in a growing city in Florida. Must be thoroughly experienced in office management, customer and general accounting, operation and maintenance of plant. Engineering degree desirable but not necessary if qualified by experience. Box 931A, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Positions Wanted

Water engineer and chemist desires top supervisory position. 8 years' experience lime-soda softening plant (60 mgd), 2½ years' industrial water conditioning, primary sewage and biological waste treatment, and power experience. Write Box 932W, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

ION EXCHANGE RESINS protect ultra-modern power plant


Influent Solution Na^+, K^+, Ca^{++}, SiO_2
Mg^{++}, Cl^-, $CO_3^=$, $SO_4^=$, HCO_3^-
Mixture: Anion and Cation Exchangers
Free Base and Hydrogen Forms
Solution. No ions
Effluent Solution to Condenser Wells

Low 0.001 ppm Silica Content of AMBERLITE-Treated Water Keeps Powerplant Turbines Clean as New for Five Full Years

AMBERLITE-treated water has practically eliminated causes of maintenance downtime on boiler and turbines at Louisiana Power & Light Company, Ninemile Point steam electric generating station near Westwego, Louisiana.

When a turbine was opened for the first time in five years of operation, there were no signs whatever of deposits. Iron oxide deposits on boiler parts are described as "very low".

Using a MONOBED mixed bed of AMBERLITE IR-120 cation exchange resin and AMBERLITE IRA-401 anion exchange resin, LP&L supplies water with less than 0.1 ppm total solids content to generating equipment. The unit is rated at 14,600 gallons with an influent of 380-mmho and effluent quality averaging 0.4 mmho.

LP&L reports results are better than an evaporator would give with the same water supply. The pH runs approximately 6.8 to 7.0. Regeneration of the MONOBED unit is completely automatic.

Consult your engineering company experienced in water treatment for full information on how AMBERLITE exchange resins may help to solve your needs for deionized, softened, dealkalized or deacidified water. Write for your copy of our booklet "If You Use Water".

AMBERLITE *and* MONOBED *are trademarks, Reg. U.S. Pat. Off. and in principal foreign countries.*

Chemicals for Industry

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Index of Advertisers' Products

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Activated Silica Generators:
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Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
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(See Professional Services)

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Permutit Co.
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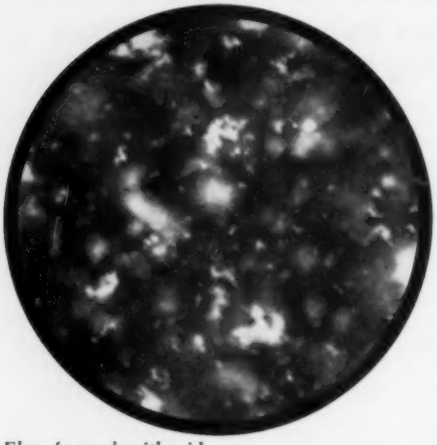


Floc formed with aid of activated silica sol

HOW BIG IS YOUR FLOC?

It's snowflake size when you coagulate with the aid of N-Sol activated silica. The larger, heavier floc enmeshes more impurities and suspended matter, which settle rapidly, producing sparkling clear water.

N-Sol is conveniently made in your plant with N sodium silicate and a reacting chemical. Let us send you a sample of N silicate with directions for jar tests.

PQ SOLUBLE SILICATES

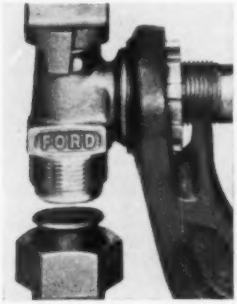
PHILADELPHIA QUARTZ CO.
1142 Public Ledger Bldg., Philadelphia 6, Pa.

Trademarks Reg. U.S. Pat. Off.

can YOUR water meters be installed with one hand . . . in 9 seconds?

NOW . . . low-cost Ford yokes make possible new standards of speed and simplicity in meter setting or removal

The Ford yoke shown above can make water meter installation a lightning-quick operation for your maintenance crews . . . cut meter installation time and cost.



Improved Valve, which can be provided as part of Yoke, does away with loose connecting ring, includes standard copper tube nut. Result is easy-to-make, leak-proof joint.

Here's how: With the Ford yoke holding inlet and outlet piping in fixed position (see photo), the meter is 1) simply set in place on the yoke, and 2) made water-tight by a manual expansion connection. The complete job takes only 9 seconds! Yet, speed isn't the only advantage of a Ford yoke. Equally important: Subsequent meter changes need never disturb service line spacing or alignment, eliminating a frequent source of trouble and leaks.

Millions of Ford yokes are in service all over the nation and Latin America . . . proving every day that there is almost no installation that can't be made better with a Ford yoke. Find out now how much maintenance time and money these low-cost units can save you.

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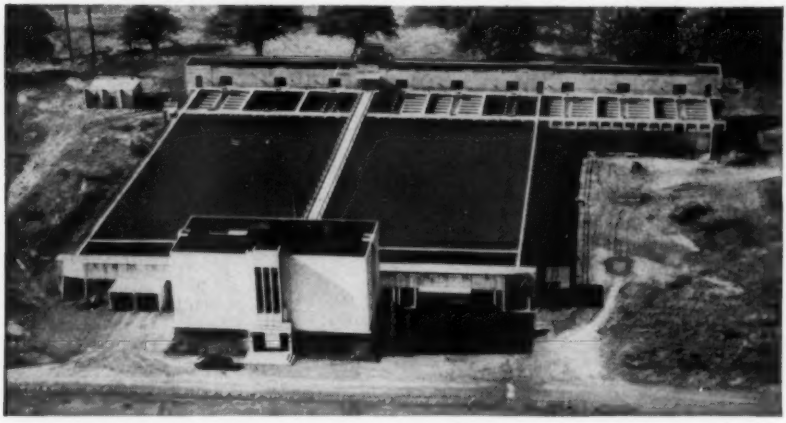
7 YEARS of outstanding service!

Inertol® coatings protect Hayden Bridge Filtration Plant, Eugene, Oregon



Ramuc® Mildew-Resistant Enamel guards 250-foot-long tunnel connecting headhouse with pumping section. Flanked on either side by one million gallons of cold water in twin reservoirs, the warmer tunnel is subject to heavy condensation and dripping. Tunnel is but one of many Inertol-protected areas of this plant.

Pacific Northwest's Largest Municipal Water Plant

The largest municipal water filtration plant in the Pacific Northwest, the 37.5-MGD Hayden Bridge installation serves over 60,000 persons in the fast-growing Eugene metropolitan area.

Inertol coatings, specified for this plant by Consulting Engineers Stevens & Thompson, Portland, provide attractive, cost-cutting protection . . . safeguard surfaces against condensation, mildew, abrasion, submersion and weather.

Specifications for Ramuc Mildew-Resistant Enamel

A glossy, mildew-resistant, chlorinated natural rubber-base coating, in color, for non-submerged concrete, steel and indoor wood surfaces.

Concrete Surfaces: *Colors:* color chart 560. *No. of coats:* one coat *Ramuc* Mildew-Resistant Enamel over two coats *Ramuc* Undercoater. For flat finish, two coats *Ramuc* Mildew-Resistant Flat to bare masonry—omit undercoater. *Coverage:* 250 sq. ft. per gal. per coat. *Approximate mil thickness per coat:* 1.2. *Drying Time:* 24 hours. *Primer: Ramuc* Mildew-Resistant Undercoater (2 coats). *Thinners: Inertol* Thinner 2000-A for brushing; 2000 for spraying. *Application:* Brushing: *Ramuc* Mildew-Resistant Enamel—brush type, as furnished. Spraying: *Ramuc* Mildew-Resistant Enamel—spray type, add sufficient Thinner 2000 for proper atomization.

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Costs go down

as fast as the pipe!

Lancaster, Pennsylvania: Ten miles of 42-inch ID steel main are an important addition to the local water supply system. The 100 per cent Dresser-Coupled line was laid by Frank Kukurin & Sons and Alconn Utilities.

AND DRESSER-COUPLED steel pipe goes in fast! Steel pipe in lengths up to 50-feet needs fewer connections, and Dresser® Couplings make those connections fast... two man-minutes per bolt. Steel pipe is lighter... saves freight costs and provides easier handling at the job-site. When you use Dresser-Couplings to join steel pipe, you eliminate the need for expensive, specialized joining equipment. The only tool you need is a simple hand wrench. For *least initial cost* and *lowest maintenance* on your next water line, specify Dresser-Coupled steel pipe.

Two man-minutes per bolt for permanent, leak-proof joints!

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Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Allis-Chalmers Mfg. Co., Hydraulic Div.
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Simplex Valve & Meter Co.

Waterproofing:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
LaMotte Chem. Products Co.
W. A. Taylor & Co.
Wallace & Tiernan Inc.

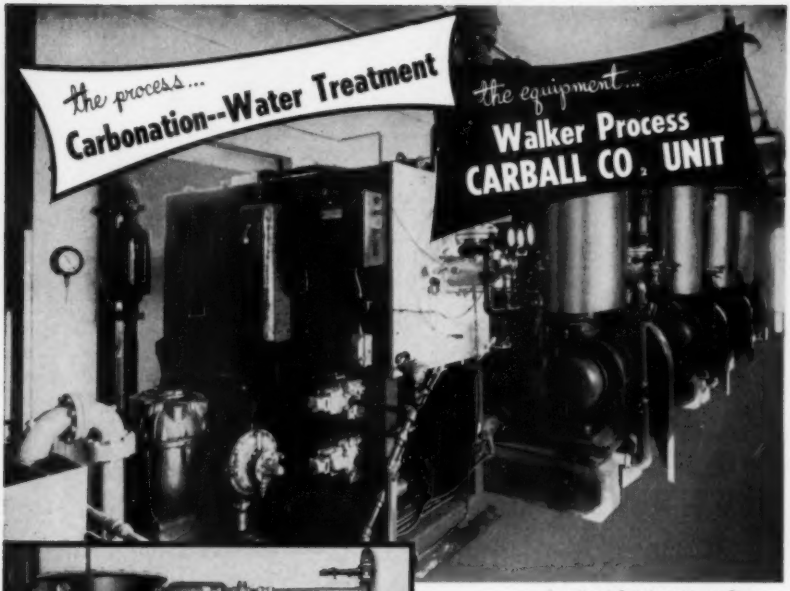
Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

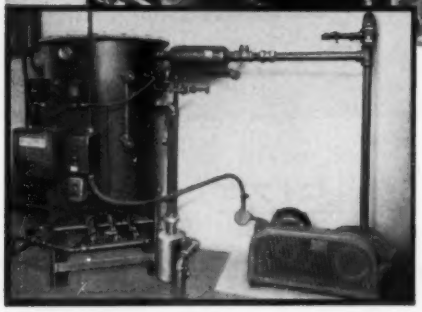
Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.





Four size 4 Carballs at Kansas City, Mo. burn either gas or oil to produce max. of 40,000 lbs. CO_2/day. Size "O" unit at left produces 570 lbs. CO_2/day for Jefferson, Iowa Water Plant.

CARBALL
CO_2 UNIT

Walker Process now offers carbonation units for all lime softening plants from the very small to the largest. Sizes range from the new "OO" unit with minimum capacity of 55 lbs. CO_2/day to the No. 4 at maximum output of 10,000 lbs. CO_2/day.

Engineers can readily provide an entire carbonation system by simply specifying the appropriate size CARBALL in combination with Walker Process SPARJER diffusers . . . . . assuring

50% More CO_2
Clean, Tasteless Gas
100% Combustion
Unique Absorption Method
Economical Operation
Factory Tested Package System

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Why has Rockwell invested a substantial sum in the development of another, bigger size magnetic meter? Because you asked for it! Based on your tremendous acceptance of our magnetic meter principle, there is now available to you a full ¾" size Rockwell Sealed Register meter to handle larger services. And more and bigger sizes are to come.

With it you can meter ¾" services with the same exclusive advantages proved the country over by thousands of ⅝" Sealed Register meter installations. These include a powerful magnetic drive which (1) eliminates the need for a stuffing box, (2) permits the use of a hermetically sealed, fog-free register and (3) provides an economical, easy to repair construction in which only two parts operate in water.

For full facts on this newest magnetic meter, write Rockwell Manufacturing Company, Pittsburgh 8, Pa.

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EDMONTON, ALBERTA

solves turbidity removal and softening problems in enlarged 40 MGD water treatment plant

Meeting the needs of its phenomenal population and industrial growth over the past decade, Edmonton has now almost tripled the capacity of its modern water treatment plant.

The original installation, incorporating the most modern lime-soda plant in Canada, went into operation in 1948 to supply 15 MGD. Dorrco Flocculators, followed by Dorrco Squarex Clarifiers, were employed to remove hardness, turbidity and color in two stages, each followed by carbonation. Addition of two sets of Flocculators and two 150′ Squarex Clarifiers now provides the Edmonton plant with a capacity for handling 40 MGD.

This new equipment was supplied by our Canadian associate, Dorr-Oliver-Long, Limited. The choice is a tribute to the excellent performance of the original installation in treating water showing 1,800 ppm turbidity, 360 ppm color and 325 ppm hardness, all of which are reduced in accordance with the high standards set for civic water supplies.

For information on the complete line of Dorr-Oliver equipment for water works installations, write to Dorr-Oliver Incorporated, Stamford, Connecticut.

Consulting Engineers on Concrete Design: Kastern, Longworth and Associates Limited, Edmonton, Alberta.

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Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

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